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THE TAXONOMY OF THE MALLOPHAGAN FAMILY TRICHODECTIDAE, WITH SPECIAL REFERENCE TO THE NEW WORLD FAUNA

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The mallophagan family Trichodectidae includes those members of the suborder Ischnocera in which the tarsi are one-clawed and the antennae in one or both sexes have either a reduced number of segments or the last two segments greatly reduced in size. The members infest mammals exclusively. They are widely distributed over the world, being best represented in Africa and North America, somewhat poorly represented in South America, and absent in Australia except on introduced domesticated animals.

Prior to 1929 this family contained only four genera, with most of the species included in the type genus. Early in that year the present writer broke up this genus into five genera, creating four new ones. Ferris (1929) has expressed doubt as to the value of such genera. Yet it is of interest to note that since that time another worker, G. A. H. Bedford, has established no less than eight new genera in the Trichodectidae, seven of them being derivatives of the same genus *Trichodectes,* and two of them acknowledged synonyms of two of the writer's genera.

For several years Bedford has been studying the African species of Trichodectidae, and in two papers, one on the Trichodectidae of dassies, or rock rabbits (Bedford, 1932*a*) and one on the Trichodectidae of African Carnivora (Bedford, 1932*b*), has given us a good summary of many, if not most, of the known species occurring in the Ethiopian region. His papers contain valuable discussions of the genera and the generic characters in the family.

The object of the present paper is to continue the consideration of these generic characters, particularly from the standpoint of a study of our American forms, and to allocate species to those genera where such allocations have not yet been made. Also, the synonymy of several species has been considered, and three new American species are described.

GENERIC CHARACTERS IN THE FAMILY TRICHODECTIDAE

The generic characters that have been used most in the family Trichodectidae have been employed in other families of biting lice, with the possible exception of the variation in the number or position of the abdominal spiracles. Notwithstanding the fact that these structures show the greatest variation in number to be found in any family of the order Mallophaga, they seldom have been mentioned either in generic or specific descriptions. This is doubtless because they are usually small and poorly pigmented, and hence are not easily seen except in stained specimens. In order to determine to what degree the different generic characters could be used to show natural groupings, the writer charted five of them for all the genera. This chart cannot be presented here, but a short summary of the results follows:

Abdominal Spiracles: In most genera of the Trichodectidae there are six pairs of abdominal spiracles, which are situated in the segments II–VII. In *Geomydoecus* and *Neotrichodectes* there are no abdominal spiracles, while in *Felicola* and *Suricatoecus* there is a reduced number. In those species in which the number of abdominal spiracles has been reduced there is said to be a varying number. However, in all such species represented in the collection of Trichodectidae in the United States National Museum, the writer has found no variation and no vestigial spiracles. In each species in which the number of spiracles is reduced, there are just three pairs, and they are always situated on segments II–IV. Because the spiracles vary so much in number between the genera, and because of the lack of vestigial spiracles, their number is believed to be the most important generic character in the family Trichodectidae. This character happily is in many instances correlated with others. The loss of spiracles is closely correlated with the reduction in sclerotization of the abdominal exoskeleton, with the loss of paratergal plates, and to some extent with the loss of tergal plates.

Antennal Characters: Antennal characters (Fig. 1) are of two kinds, —those confined to one sex and those common to both sexes. Differences between the antennae of the two sexes have always been used as generic characters in the Mallophaga, but as far as possible they should be used only as characters of secondary importance. The writer has found that some difference between the antennae of the two sexes nearly always exists in the Trichodectidae. In nearly all species examined the first segment in the male is larger, even though very slightly, or it is of a different shape than in the female. Also, when the third segment is not enlarged or curved in the male, it nearly always possesses posterior terminal spines that are not found on the antennae of the female. Where there is a difference in the number of antennal segments between the sexes, this fact should always be given in generic descriptions.

Development of the Hair-Groove (Ventral Median Groove) of the Head: One character that has not received the proper attention is the development of the hair-groove. Its correlated character, however, the development of the anterior median notch of the clypeus (Fig. 1), has received some attention. In most genera of Trichodectidae the ventral surface of the head along the median line has been incurved to form a groove. This is an adaptation to enable the head of the louse to be applied more effectively to a hair of the host. The development of this groove may be correlated with mandibular changes, so that the mandibles and groove working together make an efficient "hold-fast" organ. In some species of *Bovicola* there is no hair-groove, and in no species of this genus does it appear to be well developed. *Eurytrichodectes* (Fig. 1) has a very poorly developed hair-groove. All species of the family examined by the writer which have a broad, deep, anterior, median clypeal notch also have a well-developed hair-groove.

Eyes: The absence of eyes having been observed in the genus *Geomydoecus* (Fig. 1), it appeared worth while to investigate the eyes of all the genera. In no other genus were they found entirely missing, but in the related genus *Neotrichodectes* they were observed to be frequently poorly developed or vestigial. The same was found to be true of *Eutrichophilus.*

Male Genital Armature: The diagramming of the types of male genital armature has been enlightening. Not only are the types many, but the breaks between them are usually very marked and definite. In addition to the movable parts, in some genera, *Trichodectes* for example, there is developed about the genital opening a genital papilla with sclerotized plates. Also ventrally a definite genital area frequently is indicated by a well-sclerotized plate, the genital plate; or, if a genital plate is absent, this area frequently is inclosed laterally by a pair of genital rods. Finally, there may be developed between the posterior ends of these rods a sclerotized piece, which may be called the "posterior genital sclerite."

The movable genital armature of the members of Trichodectidae (Fig. 2) exhibits two peculiarities. One is the development of a movable articulating sclerite between the base of each paramere and the basal plate. It is best represented in some species of the genus *Bovicola,* and doubtless arises as a detachment of a large, posterolateral tubercle of the basal plate, so evident in the genera *Geomydoecus* and *Tricholipeurus.* For this structure R. E. Snodgrass has suggested the name "arthromere" (Fig. 2). The other peculiarity is to be found in the genus *Eutrichophilus.* In this genus a study of a series of species shows that what at first appear to be the parameres (Fig. 2) are in fact the endomeres. In *Eutrichophilus setosus* these endomeres have the position, shape, and exact appearances of the parameres. Yet by comparison with other spe-

cies it is noted that the true parameres are the small lateral basal processes (Fig. 2), and that the styliform endomeres found in some forms have lost their anterior process, have shifted their position laterally so that they articulate with the distal surface of the arthromere, and have become curved and somewhat clasperlike.

To describe the fundamental types of the male genital armature in Trichodectidae would require many pages, as most genera have a distinctive type. Variations in the size, shape, degree of sclerotization, and pigmentation of the different parts of the male genital armature are the most important diagnostic characters for species.

KEY TO THE GENERA OF TRICHODECTIDAE

1. Abdomen with six pairs of spiracles situated on segments II–VII; paratergal plates usually well developed 2
   Abdomen either with less than six pairs of spiracles or with no spiracles; paratergal plates usually not well developed, and sometimes absent .. 11
2. Clypeus without median notch; hair-groove poorly developed or absent; head and parts of body studded with small setae. On ungulates. *Bovicola* Ewing
   Clypeus nearly always with a median notch; hair-groove usually well developed, always present; head seldom studded with small setae 3
3. Antennae of female 3- to 5-segmented; temporal lobes large, sometimes each with a posterior process. On rock rabbits, or members of the family Procaviidae 4
   Antennae of female 3-segmented, or indistinctly 4-segmented; temporal lobes without posterior processes. Not on members of the family Procaviidae 7
4. Head considerably wider than long; temporal lobes each with a conspicuous posterior daggerlike process; female with trabeculae developed into long, ventral, recurved, hooklike processes ..... *Eurytrichodectes* Stobbe
   Head about as wide as long; temporal lobes either without daggerlike processes or these processes greatly reduced 5
5. Forehead triangular, the lateral margins almost straight; temporal bands present; esophageal sclerite present ..... *Procavicola* Bedford
   Forehead not triangular, lateral margins either inwardly or outwardly curved; temporal bands absent 6
6. Claws of legs II and III spinose-serrate on inner margins; esophageal sclerite absent or rudimentary ..... *Dasyonyx* Bedford
   Claws of legs II and III not spinose-serrate; esophageal sclerite well developed ..... *Procaviphilus* Bedford
7. Forehead more or less trapezoidal; hair-groove very large and wide. On ungulates or porcupines 8
   Forehead not trapezoidal; hair-groove very deep but not so broad 9
8. Third antennal segment of female longer than second and frequently more or less divided into two segments by a transverse suture; spiracles not swollen or bulbous; genital armature of male peculiar in that usual position of parameres is taken by styletlike endomeres (Fig. 2) while parameres are greatly reduced and entirely lateral in position. On American porcupines ..... *Eutrichophilus* Mjöberg
   Third antennal segment of female frequently shorter than second and never divided by a transverse suture; spiracles swollen and bulbous. On deer and antelopes ..... *Tricholipeurus* Bedford

9. Forehead triangular, sides about straight 10
Forehead not triangular, male provided with a dorsal genital papilla; parameres free; endomeres poorly developed and somewhat platelike. *Trichodectes* Nitzsch

10. Clypeus with a deep V-shaped median notch (Fig. 1), which is deeper than wide; genital plate present in male and with a large, bilobed, posterior sclerite. On certain ungulates of families Antelopidae and Bovidae. *Damalinia* Mjöberg
Clypeus with a small, shallow median notch; head as broad as long. On aardwolf ..... *Protelicola* Bedford

11. Abdomen with 3 pairs of spiracles situated on segments II–IV* 12
Abdomen without spiracles; paratergal plates reduced in numbers or absent 13

12. Forehead triangular (Fig. 1), median notch present. Occurring in all continents ..... *Felicola* Ewing
Forehead not triangular, without median notch. Occurring only in Africa ..... *Suricatoecus* Bedford

13. Abdominal segments I–III with paratergal plates; eyes absent; first antennal segment of male (Fig. 1) and second of female usually with an appendage; internal sac of male genitalia with hooklike denticles, endomeral plate not bifurcate distally; thoracic spiracles ventrolateral, not visible from above. On rodents of the family Geomyidae. *Geomydoecus* Ewing
All abdominal segments including I–III without, or at most with vestigial, paratergal plates; eyes present but usually degenerate; first antennal segment of male as well as second of female without appendage; endomeral plate ending in a pair of daggerlike processes distally, which serve as guides for the pseudopenis ..... *Neotrichodectes* Ewing

The Genus *Eutrichophilus* Mjöberg (1910), *sensu stricto*

The genus *Eutrichophilus* Mjöberg (1910) originally included species from deer and porcupines. In 1929 Bedford established his genus *Tricholipeurus* for certain species found on antelopes. The deer-infesting species of *Eutrichophilus* should be transferred to *Tricholipeurus*.

The genus *Eutrichophilus* includes the following previously described species, all of which have been previously assigned to it:

Eutrichophilus cercolabes Mjöberg from *Cercolabes prehensilis*.
Eutrichophilus coëndu Stobbe from *Coëndou mexicanus*.
Eutrichophilus cordiceps Mjöberg from *Cercolabes prehensilis*.
Eutrichophilus mexicanus (Rudow) from *Cercolabes mexicanus*.
Eutrichophilus minor Mjöberg from *Cercolabes prehensilis*.
Eutrichophilus setosus (Giebel) from *Erethizon dorsatum*.

These six species come from just half that many type hosts (the generic name *Cercolabes* in this type host list is only a synonym of *Coëndou*), one from northern North America, one from Mexico, and one from South America.

* According to some authors there may be four pairs of spiracles on the abdomen, but the writer has never observed that number on any specimen he has examined.

In the several collections located in Washington there are seven distinct, though rather closely related, species of *Eutrichophilus* which represent specimens taken in various localities scattered from Alaska to Paraguay. Three of these are new, two being here described. The other new species, represented only by two broken females, is not described.

Eutrichophilus lobatus, New Species. (Fig. 2.)

Male: Forehead triangular; median notch small, crescentic. Antennae very large and reaching backward beyond posterior margin of prothorax; first segment about as long as II and III together, broadest at its base and with axis slightly curved; second segment much shorter than third, slightly swollen on inside and with

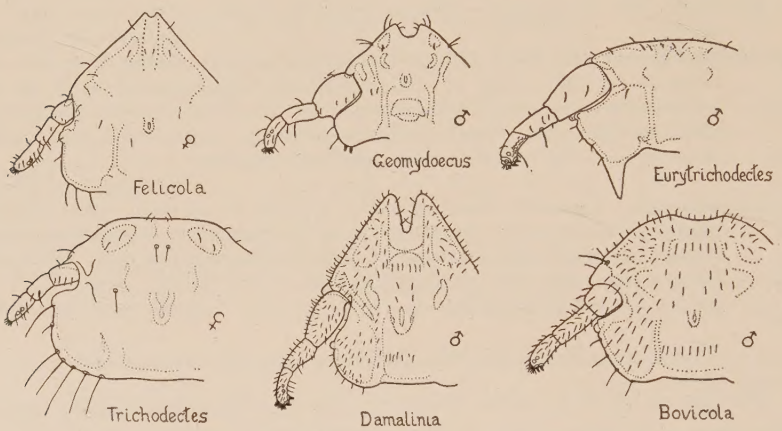

FIG. 1. Heads of the type species of six genera of Trichodectidae (not equally enlarged): *Felicola subrostrata* (Nitzsch), *Geomydoecus geomydis* (Osborn), *Eurytrichodectes paradoxus* Stobbe, *Trichodectes canis* (Degeer), *Damalinia crenelata* (Piaget), *Bovicola caprae* (Gurlt). All views dorsal.

outer margin longer than inner; third segment strongly curved, its terminal spines approximate and each but slightly longer than wide at base. Segment VIII of abdomen distinct from IX and formed into two broadly rounded distal lobes below, each bearing a tuft of long setae; segment IX about two-thirds as broad as VIII, and also bilobed distally. Genital armature (Fig. 2) with broad basal plate, lateral margins of which become much thickened toward distal end for articulation with endomeres and parameres; endomeres separate, stout, slightly curved distally but not hooked, each articulating at its base with inside of projecting thickened lateral margin of basal plate and inside of paramere; parameres short plates, apparently fusing with reduced arthromeres.

Length, 1.79 mm.; width, 0.73 mm.

Female: Head smaller than in male, and forehead not nearly as broad. Segments VIII and IX of abdomen much smaller than in the male and only slightly bilobed. So-called gonapophyses (hair-claspers) simple, curved, well sclerotized, situated laterally to segment VIII.

Length, 1.65 mm.; width, 0.69 mm.

Type host.—*Coendou pruinosus.*

Type locality.—"South America."

Type slide.—U.S.N.M. No. 50060.

Described from one male and one female which were part of a lot consisting of a male, female, and three nymphs taken from the skin of type host (U.S.N.M. 172985) coming from "South America." This species is near *coëndu* Stobbe, but has a broader head, the last two segments of the abdomen differently shaped, and a different genital armature.

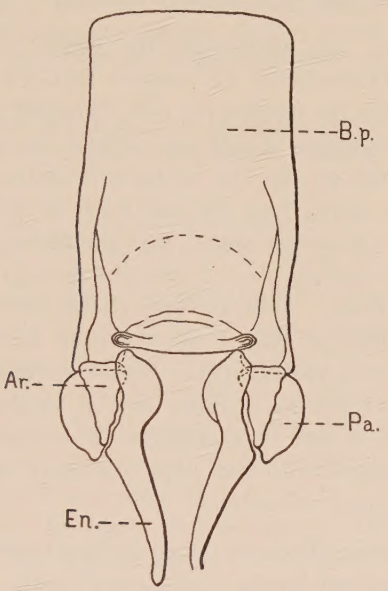

FIG. 2. Ventral view of genital armature of male of *Eutrichophilus lobatus*, new species. *Ar.*, arthromere; *B.p.*, basal plate; *En.*, endomere; *Pa.*, paramere.

Eutrichophilus australis, New Species

Female: Forehead trapezoidal, with a very broad and very shallow anterior median notch. Hair-groove broad and deep, about a third as broad as head. First segment of antenna slightly swollen, about as long as second; second shorter than third; third slightly clavate and bearing the two subequal sense organs on its posterior margin near the apex, each being at a distance equal to about its diameter from the other. Eyes with conspicuous, strongly rounded corneas. Temporal lobes somewhat angulate behind. Thoracic spiracles well developed but concealed from above by the projecting pronotum. Abdomen with sides subparallel; spiracles small, subequal; sixth abdominal segment without, seventh with, lateral tufts of long setae; paratergal plates of eighth abdominal segment very large, freely projecting, cupped and each bearing on its ventral margin a fringe of evenly spaced setae. These paratergal plates doubtless function as gonapophyses. They are movably hinged to the paratergal plates of the seventh segment.

Length, 2.26 mm.; width, 0.74 mm.

Type host.—*Coendou villosum.*

Type locality.—Sapucay, Paraguay.

Type slide.—U.S.N.M. No. 50061.

Described from two females, taken from skins of type host, collected at type locality. They constitute a part of two lots with data as follows: One female from skin U.S.N.M. No. 115121 and one female and three

nymphs from skin U.S.N.M. No. 115123. This species comes next to *cercolabes* Mjöberg, but differs from Mjöberg's species in having the forehead trapezoidal instead of subtriangular, a much broader hair-groove, and the sides of the abdomen subparallel.

The Genus *Suricatoecus* Bedford (1932)

Bedford (1932*b*) has established the genus *Suricatoecus* for an African species of *Trichodectes* (*T. cooleyi* Bedford) found on a mongoose. In this species the forehead is not triangular; yet there are three pairs of abdominal spirales, which are situated on segments II to IV. Into this genus should go also the writer's *Trichodectes abnormis,* collected from a lemur taken from the east coast of Madagascar. In the original description the writer stated that the abdominal spiracles were missing. By a very careful play of the light through the microscope he has now discovered them. They are very poorly sclerotized and without pigment, but it is believed that if the specimen had been stained they would have shown up conspicuously. These spiracles are on segments II to IV, as in *Suricatoecus.*. Since only a single male specimen of *abnormis* was taken, it may be a straggler from some carnivore. The two species of this genus, with their type hosts, are here listed, *abnormis* being transferred from *Trichodectes.*

Suricatoecus cooleyi (Bedford) from *Suricata suricatta hamiltoni.*
Trichodectes abnormis Ewing from *Lemur rufus.*

The Genus *Geomydoecus* Ewing (1929)

This genus is the most modified, from the generalized type of the family, of all the contained genera. The species are blind (Fig. 1), without abdominal spiracles, without tergites, and usually with only the first three pairs of paratergal plates, and some of these may be much reduced. These degenerative changes, however, have been matched by the development of specialized structures. The antennae, for example, are modified more than in any other genus, usually having one or two processes (Fig. 1) in both sexes and strongly adapted for clasping in the male. The male genital armature is very complicated and highly modified, but is exceeded in this respect by those of *Neotrichodectes* and American species of *Tricholipeurus.* The described species of *Geomydoecus* and their type hosts follow:

Trichodectes californicus Chapman (1897) from *Perognathus* sp.
Trichodectes expansus Dugès (1902) from *Geomys* sp.
Geomydoecus geomydis (Osborn) (1891) from *Geomys bursarius.*
Trichodectes scleritus McGregor (1917) from "gopher."
Trichodectes thomomyus McGregor (1917) from *Thomomys* sp.

All species in this list, except the type species, *geomydis,* are here allocated to *Geomydoecus* for the first time, and all but one (probably a straggler) come from that rather aberrant rodent family Geomyidae. A new species is described as follows:

Geomydoecus texanus, New Species

Male: Like male of *geomydis* (Osborn) (Fig. 1) except that first antennal segment has outer margin less arched and is without process, and last antennal segment less curved.

Length, 1.48 mm.; width, 0.75 mm.

Female: Like female of *geomydis* (Osborn) except that anterior median notch is deeper and lateral margins of forehead are more emarginate.

Length, 1.26 mm.; width, 0.68 mm.

Type host.—Geomys personatus fallax.

Type locality.—Corpus Christi Bay, Flour Bluff, Tex.

Type slide (holotype, the male).—U.S.N.M. No. 50062.

Material as follows: Male, female, and three nymphs from type host and type locality, July 22, 1929, by Francis Harper; two females and three nymphs from type host and type locality, July 23, 1929, by Francis Harper; two males, two females, and two nymphs, from *Geomys personatus,* Kinney County, Tex., August 8, 1929, by Francis Harper. This is the only species in the genus in which the antennae of the male have no processes while those of the female do.

Much care should be taken in studying the antennae in species of *Geomydoecus.* If they are not in their usual position, the processes do not show up readily. These structures may always be detected, however, by focusing up and down with the microscope, varying the light intensity at the same time.

In the several collections located in Washington there are about two dozen lots of specimens which doubtless would be regarded by some workers as belonging to Osborn's *geomydis.* Those specimens coming from California, of which there are thirteen lots, show a consistent difference from those of *geomydis* found on its type host, *Geomys bursarius,* in the shape of the first segment of the antennae of the male. In the males from California the posterior process is distinctly thumblike and conspicuous, while the antennal segment itself is but slightly swollen about the base of the process. In the males from *Geomys bursarius* the posterior process is low, not thumblike, and inconspicuous, while the segment iself is expanded about the base of the process. For these reasons the writer believes that Chapman's species is distinct notwithstanding the fact that it has long been regarded as a synonym of *geomydis.*

There are three lots of *Geomydoecus* from the State of Washington at the U. S. National Museum, one from *Thomomys fuscus,* one from *Thomomys douglasi,* and the other representing a single straggler, from a meadow mouse, which agree fairly well with McGregor's type of

thomomyus. In this species the male genital armature is distinctive in that the pseudopenis is absent and the endomeral plate extends far back of the parameral arch.

Dugès' *expansus* was described (Dugès, 1902) as a variety of *geomydis,* differing from the type form, according to its author, in having a broader abdomen, tridentate mandibles, and spines on the posterior lobes of the head of the male. In the U. S. National Museum collection there are four large nymphs which apparently belong to Dugès' *expansus.* An examination of these and of many specimens of *geomydis* shows that two of the differential characters given by Dugès do not hold, since in Osborn's *geomydis* the mandibles, particularly the right one, are tridentate and the temporal lobes (posterior lobes of the head) of the male bear spines (two on each lobe).

Dugès' *expansus,* however, not only is a distinct species but differs from all the others in the great width of its head, which is twice as wide as long. Also, it is decidedly larger than any of the other species.

An examination of the types of McGregor's *scleritus* shows that this species is extremely near Osborn's *geomydis* and may possibly be reduced to either a variety or a synonym of that species. Until the male is found, however, it is best to retain *scleritus* in its present status. The only consistent difference that the writer has found between it and *geomydis* is in the shape of the trabeculae; yet there is some variation in this character. It remains to be seen whether this is correlated with either host or geographical distribution.

The Genus *Neotrichodectes* Ewing (1929)

Neotrichodectes shares with *Geomydoecus* the loss of abdominal sclerites (in some species all of them being gone) and of all the abdominal spiracles. It differs from that genus in possessing eyes, in always having antennae without processes, and in having an endomeral plate (in the male genital armature) that ends in a pair of daggerlike projections distally which serves as guides for the pseudopenis. *Neotrichodectes* and *Geomydoecus* make a natural group in the Trichodectidae. The first-named genus connects this group with the American species of *Trichol*i*peurus* on the one hand—the two groups of species have the same type of male genital armature—and with *Felicola* on the other. The connection with *Felicola* is shown through the mongoose-infesting species, *Neotrichodectes helogale,* and the genet-infesting species, *Neotrichodectes genetta.* The first-named species was described under the generic name of *Felicola* and the second under that of *Trichodectes.* Both these species have been recently placed with some hesitation (Bedford, 1932*b*) in *Felicola.* Possibly they should be put into a genus of their own. The following species are here allocated to *Neotrichodectes,* only the type having been previously included:

Trichodectes castoris Osborn from "beaver."
Trichodectes gastrodes Cummings from *Choloepus didactylus.*
Trichodectes genetta Bedford from *Genetta felina ludia.*
Felicola helogale Bedford from *Helogale parvula brunnula.*
Trichodectes interrupto-fasciatus Kellogg and Ferris from *Taxidea taxus* and a "skunk."
Neotrichodectes mephitidis (Packard) from *Mephitis* sp.
Trichodectes mephitidis Osborn from *Spilogale interrupta* and *Mephitis mephitica.*
Trichodectes minutus Paine from *Putorus noveboracensis.*
Trichodectes nasuatis Osborn from *Nasua narica.*
Trichodectes pallidus Paiget from *Nasua fusca.*
Trichodectes thoracicus Osborn from *Bassaris astuta.*

Questionably included are:

Trichodectes barbarae Neumann from *Galictis barbara.*
Trichodectes exilis Nitzsch from *Lutra vulgaris.*
Trichodectes mustelae Schrank from *Mustela vulgaris.*

Synonyms are:

Trichodectes monticolus McGregor = *Trichodectes mephitidis* Osborn, not Packard.
Trichodectes dubius Nitzsch = *Trichodectes mustelae* Schrank.
Trichodectes pusillus Nitzsch = *Trichodectes mustelae* Schrank.

Osborn's *mephitidis,* which is a secondary homonym, may be only a synonym of Packard's *mephitidis.* The latter is not a bird louse at all, as has been assumed by Kellogg and Ferris (1915), but a true trichodectid, as Packard's figure and description clearly show.

These same authors, quite without justification, have placed Paine's *Trichodectes minutus,* which was based on specimens collected by the writer from a weasel in Illinois, as a synonym of Osborn's *mephitidis.* The common louse of the weasel in the eastern part of the United States differs from *mephitidis* in size, in the shape of the temporal lobes and of the first segment of the male antennae, and in other minor points. However, their identification of the California *Trichodectes* on skunks as Osborn's *mephitidis* appears correct, since the types of McGregor's *monticolus,* taken from a California skunk, appear to be no other than *mephitidis.*

The writer has had three specimens of Osborn's type material of *Trichodectes castoris* remounted, one of them being stained. An examination of these specimens shows that the species is a typical *Neotrichodectes,* having no abdominal sclerites, no abdominal spiracles, and

degenerate eyes. It is closely related to *mephitidis* Osborn and *minutus* Paine, differing from the former in having but a slight indication of an anterior median notch to the clypeus and in the shape of the first antennal segment of the male, and from the latter in the shape of the trabeculae and the temporal lobes, which are somewhat angulate behind as in *mephitidis* Osborn. Since this species is typical of those infesting carnivores, its occurrence on a rodent might be suspected of being due to straggling. On several occasions ectoparasites have been sent to the writer from beavers but never a specimen of biting louse.

An examination of seven cotypes of Osborn's *thoracicus* shows that it is closely related to *minutus,* having the temporal lobes devoid of posterior angles, but that it differs from *minutus* in having a deeper anterior median notch, shorter setae in the dorsal row on the first antennal segment of the male, and a much smaller, posterior, marginal, temporal seta which is definitely dorsal in position.

Cummings' *gastrodes,* based on five specimens in poor condition ("the specimens had been attacked by a species of mite"), comes in *Neotrichodectes,* having the genital armature and other characters typical of the genus. Its occurrence on an edentate may have been due to straggling. American edentates are remarkably free from ectoparasites. The writer knows of no well-established case of louse infestation on them, notwithstanding the existence of certain records, which probably apply to stragglers.

The Genus *Trichodectes* Nitzsch (1818), *sensu stricto*

The various recent generic subtractions from *Trichodectes* leave it with eighteen good, or apparently good, species. Fourteen of these come from carnivores and four from monkeys. One of the carnivore-infesting species is found on bears. The present writer has not had the opportunity to examine any of the monkey-infesting species. The bear-infesting species, *Trichodectes pinguis* Nitzsch, has the same type of movable genital armature as the type species of *Trichodectes, T. canis* Degeer, but the paratergal plates do not appear to be typical of this genus.

In the United States there are two species of *Trichodectes* that infest dogs. One of these is the type species, *Trichodectes canis* Degeer, and the other is *Trichodectes floridanus* McGregor (1917). *Trichodectes floridanus* differs from *T. canis* in having a more pronounced anterior median emargination to the clypeus, much larger dorsal tubercles on the head and a thorax with postero-lateral angles to its posterior border. The following specimens of *Trichodectes canis* have been examined and identified: Two males and 1 female from dog, R. W. Wells, Starkeville, N. Y., June 16, 1921 (Bishopp No. 10203) ; 5 females from dog, Washington, D. C.; 1 female from dog, West Milton, Ohio, June 5, 1933; 2

females from dog, F. C. Bishopp, Fillmore, Ind., September 15, 1930 (Bishopp No. 14727); 5 males, 9 females and 1 nymph, from coyote, S. G. Jewett, Coos County, Ore., December, 1923; 1 male and 2 females from dog, E. B. Marshall, Charlotte, N. C., September 22, 1931 (Bishopp No. 18071); 2 females and 2 nymphs from dog, Y. Hsu, Soochow, China, 1929.

In addition to the types of *Trichodectes floridanus,* a single lot of specimens of this species was examined. Data for the latter follow: Two females from dog, F. Y. S. Moore, McAlester, Okla., 1929.

Two specimens of *Trichodectes canis* taken from a coyote are so close to those taken from dogs that it does not seem advisable to describe them as representing a new variety. They do not show, however, any suggestion of a median anterior clypeal notch, while some of the specimens from dogs show a very slight median anterior emargination. The specimens taken from a dog at Charlotte, N. C., are somewhat intermediate between *canis* and *floridanus,* but nearer the former.

The Genus *Bovicola* Ewing (1929)

The genus *Bovicola* was established in 1929 by the writer for bovine-infesting species of *Trichodectes.* It should be enlarged, temporarily at least, to include all those ungulate-infesting members of the family Trichodectidae remaining in the type genus *Trichodectes* that show closer affinities to this genus than to any of the other more recenty established ones. The three species found on hosts of the family Camelidae, the four on members of the family Equidae, and the one on a species of Suidae apparently are more closely related to the genus *Bovicola* than to *Trichodectes.* Because of the lack of material the writer has not had an opportunity to go into the synonymy of the species of this genus.

That the species of *Bovicola* are related to the rather unusually shaped species of *Damalinia* is shown by their chaetotaxy. In both these genera (Fig. 1) the head is studded with small setae and there is a transverse discal row of setae on the clypeus and also on the epicranium.

The Other Genera of Trichodectidae

There remain eight genera of the Trichodectidae that have not been given any special consideration in this paper. Six of them, *Eurytrichodectes, Procavicola, Dasyonyx, Procaviphilus, Damalinia,* and *Trichelicola,* are African and have been given adequate treatment by Bedford, particularly in his two recent papers (Bedford, 1932*a,* and 1932*b*). The other two, *Tricholipeurus* and *Felicola,* are almost world-wide in their distribution. The former has been dealt with by Bradford (1929) and the latter by the same author (1932*b*).

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NEW AVIAN TREMATODES OF THE GENUS *NEODIPLOSTOMUM*

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Neodiplostomum paraspathula n. sp. Figs. 1–3.

Family Alariidae Tubangui, 1922; subfamily Neodiplostominae Dubois, 1932.

OCCURRENCE

Thirteen specimens of what is evidently a new species of the genus *Neodiplostomum* Railliet, 1919, were taken from the intestine of a hawk, *Archibuteo ferrugineus,* on October 29, 1934. The bird was captured near Stockton, California. Certain similarities to *Neodiplostomum spathula* (Creplin, 1829) La Rue, 1926, and with *Neodiplostomum pseudospathula* (Brandes, 1890) Ciurea, 1928, have suggested the name *Neodiplostomum paraspathula* which is herewith proposed for the species.

SPECIFIC DESCRIPTION

External Features.—Body 2.1–2.8 mm. in length; forebody equal to or slightly longer than hindbody, separated by distinct constriction. Forebody flattened, 0.69–0.94 mm. across anterior quarter, and lateral margins curved ventrally in most specimens. Subterminal oral sucker, 0.060–0.090 mm. in diameter, and acetabulum, 0.067–0.094 mm. in diameter, approximately equal in size; latter organ in about center of forebody. Holdfast organ, 0.28–0.53 mm. long, 0.23–0.47 mm. broad, elliptical in outline, about one-third length of forebody, between acetabulum and posterior end of forebody, with no portion hidden by ventral fusion of lateral body margins. No lateral sucking cups or specialized glands developed on forebody, but very fine spines, more numerous and larger at anterior end, covering forebody from oral sucker to region of holdfast organ.

Hindbody roughly cylindrical but with widest diameter, 0.48–0.68 mm., at about middle of length. On its dorsal surface, near the posterior end (fig. 2), is the opening,, extremely variable in size, into the genital atrium; it is not marked by ridges, protuberances or other modifications of the body wall. Excretory pore, also on dorsal surface, opens posterior to genital atrium and very near posterior end of body.

Digestive System.—Very short prepharynx, 0.008–0.010 mm. long, connects mouth with pharynx, 0.052–0.067 mm. long, 0.045–0.060 mm. wide. Length of esophagus, 0.067–0.12 mm., depends upon state of contraction or extension of anterior part of body. Intestinal ceca pass ventrally over reproductive glands in hindbody, curve dorsally around posterior limits of posterior testis, and terminate near genital atrium. They are narrower, 0.013–0.030 mm., in forebody and of larger diameter, 0.023–0.038 mm., in hindbody.

Female Reproductive Organs.—Ovary, 0.125–0.156 mm. long, 0.195–0.234 mm. wide, 0.172–0.190 mm. thick, in anterior quarter or anterior third of hindbody, usually a little nearer left than right side. Oviduct arises as narrow continuation of small conical projection on postero-dorsal surface of ovary, forming a small

loop in a dorsal to ventral direction followed by a larger loop in opposite direction (fig. 2). A thicker walled enlargement, 0.025–0.035 mm. in diameter, occurs in center of latter loop which is probably the fertilization chamber. Laurer's canal unites with oviduct very near enlargement and opens on dorsal surface on a level with posterior margin of ovary. Oviduct continues posteriorly to enter Mehlis's gland at dorsal end (fig. 2) then runs ventrally and to left until, in about center of gland, it makes a dorsal loop back toward right to form oötype. It widens gradually as it again turns ventrally and emerges from ventral margin of Mehlis's gland as ascending uterus. Ascending uterus passes left side of ovary and, anterior to it at distance about equal to its length, then turns abruptly to right and toward posterior end of body to continue along ventral body wall as descending uterus. At posterior end of body uterus narrows into a small duct leading dorsally and anteriorly to genital atrium (fig. 2). Genital atrium more or less spheroidal chamber, 0.075–0.140 mm. in diameter, on dorsal side of body near posterior end. Uterine eggs, 0.094 x 0.063 mm., few or absent.

Mehlis' gland, 0.109–0.180 mm. long, 0.190–0.300 mm. broad, 0.200–0.310 mm. thick, in center of body between testes, wedge-shaped with major portion on left side of body where a prominent ventral bulge also occurs. In whole mounts Mehlis' gland appears to be wholly ventral and on left side.

Vitellaria in forebody extend from one-third to slightly more than one-half distance from acetabulum to oral sucker. In hindbody they are distributed uniformly and thickly over entire ventral surface, extending over posterior end to genital atrium on dorsal side. Vitelline reservoir a conspicuous swelling, 0.06–0.09 mm. in diameter, immediately adjacent to union of paired vitelline ducts in mid-ventral region of body and to right of Mehlis' gland. Unpaired vitelline duct grows smaller as it passes dorsally from reservoir until, where it meets oviduct at its entrance to Mehlis' gland, it is equal to oviduct in size.

Male Reproductive Organs.—Testes, together with Mehlis' gland, occupy about half of hindbody; anterior quarter of hindbody contains ovary, posterior quarter contains seminal vesicle and genital atrium, intervening space occupied by testes and Mehlis' gland.

Owing to position and shape of Mehlis' gland below it, and to position of seminal reservoir above it, anterior testis, 0.202–0.290 mm. long on the right side, 0.375–0.390 mm. broad, 0.300–0.312 mm. thick, is larger on its right side where it also projects ventrally. Narrower portion on left further reduced in size by ventral excavation along which uterus and vas deferens pass (fig. 1). Posterior testis, 0.202–0.350 mm. long, 0.403–0.530 mm. broad, 0.312–0.325 mm. thick, larger than the anterior one, excavated ventrally, posteriorly and dorsally in such a manner that both transverse and longitudinal sections present horseshoe shaped figures. Posterior testis in contact with anterior one dorsally and on right.

Vas efferens of anterior testis arises from midventral surface; it passes anteriorly and to left of vas deferens, turns dorsally over testis, and enters a bladder-like seminal reservoir on left side of body between anterior testis and ovary (fig. 3). Vas efferens of posterior testis emerges from its anterior ventral position, passes anteriorly and to right of vas deferens, and joins seminal reservoir on right side. Vas deferens runs ventrally from seminal reservoir and between vasa efferentia, turns posteriorly over ventral face of anterior testis and follows excavated regions of testes just dorsal to uterus. At posterior excavation of posterior testis vas deferens widens and loops dorsally to form large seminal vesicle (fig. 3). Ejaculatory duct emerges from right side of loop and joins uterine duct just before its connection with genital atrium. It should be noted that seminal reservoir, although bladder-like in structure, is so irregular in outline and terminal portions of vasa efferentia are so large in diameter that the reservoir, together with adjacent portions of vasa efferentia and vas deferens, resembles a coiled seminal reservoir.

Habitat.—Intestine of *Archibuteo ferrugineus.*

Vicinity.—Stockton, California.

Date.—October 29, 1934.
Type.—U. S. Nat. Mus., Slide No. 8921.
Paratypes.—College of the Pacific, Stockton, California.

COMPARISONS

Six previously described species of *Neodiplostomum* resemble *Neodiplostomum paraspathula* in most particulars, but each of them differs in at least three features of taxonomic significance. These differences are listed under appropriate headings below.

Neodiplostomum spathula (Creplin, 1829) La Rue, 1926.

1. Size of ovary: approximately equal to that of anterior testis in *N. spathula*; about half the size of anterior testis in *N. paraspathula.*
2. Excavations of testes: shallow ventral excavation of posterior testis in *N. spathula*; deep ventral, posterior, and dorsal excavations of posterior testis of *N. paraspathula.*
3. Distribution of vitellaria: barely anterior to acetabulum in *N. spathula*; from one third to more than one half distance from acetabulum to oral sucker in *N. paraspathula.*
4. Position of vitelline reservoir: centrally located in *N. spathula*; ventrally located in *N. paraspathula.*
5. Size ratio of oral sucker to pharynx: equal in *N. spathula*; pharynx clearly smaller in *N. paraspathula.*

Neodiplostomum pseudospathula (Brandes, 1890) Ciurea, 1928.

1. Genital cone: present in *N. pseudospathula*; absent in *N. paraspathula.*
2. Dimensions of holdfast organ: approximately twice as long as broad in *N. pseudospathula*; slightly longer than broad in *N. paraspathula.*
3. Distribution of vitellaria: do not reach lateral margins of hindbody in *N. pseudospathula*; reach lateral margins of hindbody in *N. paraspathula.*
4. Relative sizes of testes: anterior testis larger in *N. pseudospathula*; posterior testis larger in *N. paraspathula.*

Neodiplostomum attenuatum (v. Linstow, 1906) La Rue, 1926.

1. Size of testes: small, about half the diameter of hindbody, in *N. attenuatum*; large, almost equal to diameter of hindbody, in *N. paraspathula.*
2. Anterior extent of vitellaria: To anterior margin of acetabulum in *N. attenuatum;* from one third to more than one half the distance from acetabulum to oral sucker in *N. paraspathula.*
3. Position of vitelline reservoir: centrally located, a uniform swelling of entire unpaired vitelline duct, in *N. attenuatum*; ventrally located in *N. paraspathula.*
4. Size ratio of oral sucker to acetabulum: acetabulum conspicuously larger in *N. attenuatum*; approximately equal in *N. paraspathula.*

Neodiplostomum pseudattenuatum Dubois, 1927.

1. Location of Mehlis' gland: on right side of body in *N. pseudattenuatum*; on left side in *N. paraspathula.*
2. Size of ovary: almost equal to that of anterior testis in *N. pseudattenuatum*; approximately half the size of anterior testis in *N. paraspathula.*
3. Distribution of vitellaria: heavily concentrated on lateral sides of seminal vesicle in *N. pseudattenuatum*; more uniformly distributed in *N. paraspathula.*

Neodiplostomum cochleare (Krause, 1915) La Rue, 1926.

1. Location of Mehlis' gland: on right side of body in *N. cochleare*; on left side in *N. paraspathula.*
2. Distribution of vitellaria: do not reach posterior end of hindbody in *N. cochleare*; extend around posterior end to genital atrium in *N. paraspathula.*

3. Position of vitelline reservoir: dorsally located in *N. cochleare*; ventrally located in *N. paraspathula.*

Neodiplostomum peraltum Ciurea, 1929.

1. Genital cone: present in *N. peraltum*; absent in *N. paraspathula.*
2. Distribution of vitellaria: do not reach lateral margins or posterior end of hindbody in *N. peraltum*; reach lateral margins and extend dorsally over posterior end in *N. paraspathula.*
3. Size ratio of pharynx to oral sucker: approximately equal in *N. peraltum*; pharynx clearly smaller in *N. paraspathula.*
4. Length of esophagus: very short, 0.011–0.035 mm., in *N. peraltum*; longer, 0.067–0.120 mm., in *N. paraspathula.*

Neodiplostomum orchilongum n. sp. Figs. 4–7.

Family Alariidae Tubangui, 1922; subfamily Neodiplostominae Dubois. 1932.

OCCURRENCE

On October 16, 1933, twenty-one specimens of a hitherto undescribed trematode were taken from the intestine of a great blue heron, *Ardea herodias hyperonca,* which was captured near Stockton, California. The animals evidently belong to the genus *Neodiplostomum* Railliet, 1919, and they are here described as a new species for which the name *Neodiplostomum orchilongum* is proposed.

SPECIFIC DESCRIPTION

External Features.—Body small, 1.24–1.48 mm. long, and forebody, about twice the length of the hindbody, separated from later by distinct constriction.

Explanation of Plate

All drawings were made with the aid of a camera lucida. Figures 1 and 4 are drawings of whole mounts; all others are semi-diagrammatic reconstructions of serial sections.

Abbreviations: at., anterior testis; au., ascending portions of uterus; du., descending portions of uterus; ej., ejaculatory duct; ep., excretory pore; ex., excretory channel; ga., genital atrium; gc., genital cone; lc., Laurer's canal; m., Mehlis' gland; ov., ovary; pt., posterior testis; sr., seminal reservoir; sv., seminal vesicle; v., vitellaria; vd., vas deferens; vr., vitelline reservoir.

Fig. 1. *Neodiplostomum paraspathula,* ventral view of entire animal. ×40.
Fig. 2. Hindbody of *Neodiplostomum paraspathula* viewed from the left, showing female reproductive organs. Position of Mehlis' gland indicated in outline. ×65.
Fig. 3. Male reproductive organs of *Neodiplostomum paraspathula* as viewed from the left. ×80.
Fig. 4. *Neodiplostomum orchilongum,* ventral view of entire animal. ×60.
Fig. 5. Hindbody of *Neodiplostomum orchilongum* viewed from the right, showing female reproductive organs. ×130.
Fig. 6. Dorsal view of bursa copulatrix of *Neodiplostomum Orchilongum,* showing genital cone. ×60.
Fig. 7. Male reproductive organs of *Neodiplostomum orchilongum* as viewed from the right. ×120.

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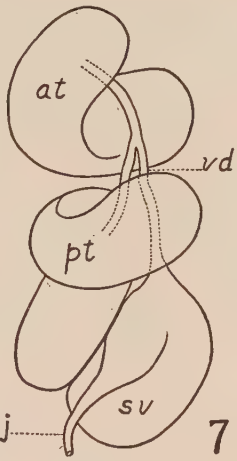
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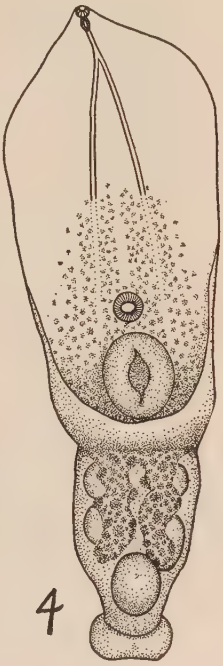
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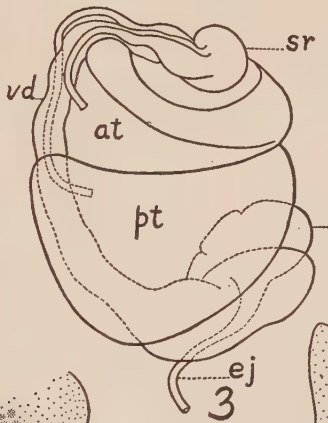
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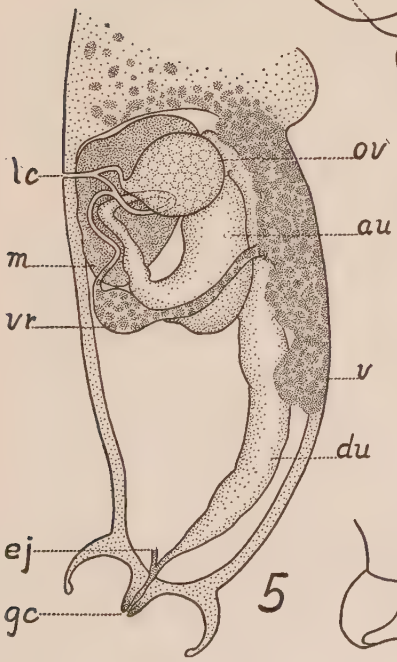
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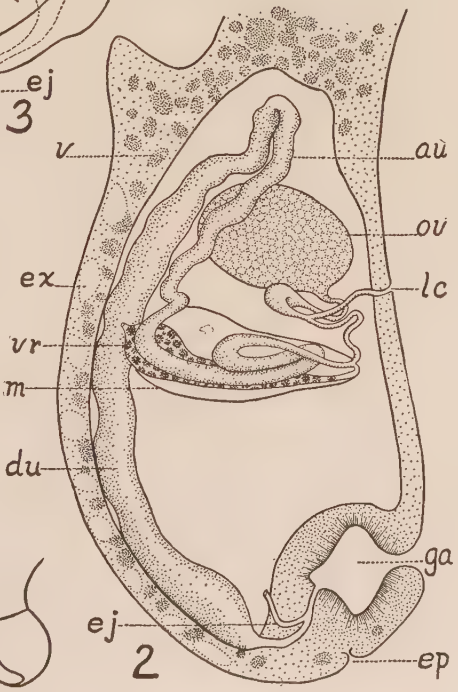
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Forebody flattened with maximum breadth, 0.467–0.494 mm., across anterior quarter of length; no lateral sucking cups or specialized glands. Subterminal oral sucker, 0.03–0.06 mm., about half diameter of acetabulum, 0.07–0.10 mm., which is located in posterior third of forebody. Immediately behind acetabulum is holdfast organ, 0.142–0.190 mm. long, 0.130–0.165 mm. wide, elliptical in outline, less than one-quarter as long as forebody, and having no portion hidden by postero-ventral fusion of lateral margins of forebody. Spines or other integumental modifications of body surface not observed.

Hindbody somewhat cylindrical in shape with greatest diameter, 0.28–0.34 mm., through center, and shortest diameter near posterior end just anterior to prominent bursa copulatrix. In all specimens available for examination bursa copulatrix, 0.056–0.078 mm. long, 0.123–0.200 mm. broad, projects dorso-posteriorly (fig. 5) in a manner resembling a cup, the sides of which fail to meet dorsally (fig. 6). It encloses a centrally located genital cone, length: 0.05–0.06 mm., basal diameter: 0.025–0.037 mm., but otherwise smooth-walled and devoid of special structures.

Digestive System.—Connection between oral sucker and pharynx can be observed in thinly-sectioned material only, appearing too short to be designated as a prepharynx. Pharynx, 0.026–0.045 mm. long, 0.024–0.035 mm. wide, approximately equal to oral sucker in size; Esophagus, 0.06–0.09 mm. long, about twice length of pharynx. Intestinal ceca pass lateral and dorsal to holdfast organ, then curve ventrally into hindbody and extend along ventral body wall to posterior third of its length, where they turn dorsally through from one quarter to one half body depth. In marked contrast to extremely thin-walled and narrow portions of ceca in the forebody, ceca in hindbody thick-walled and of larger diameter, 0.011–0.022 mm.

Female Reproductive System.—Ovary, 0.055–0.067 mm. long, 0.060–0.067 mm. broad, 0.062–0.067 mm. thick, on extreme right of anterior limit of hindbody and, in most specimens, definitely dorsal in position. Its postero-dorsal surface projects as conspicuous funnel-shaped connection with oviduct. Oviduct turns anteriorly and to left (fig. 5) and then passes dorsally in more or less straight line to juncture with Laurer's canal which opens on dorsal body surface on level with center of ovary. From union with Laurer's canal oviduct turns ventrally and posteriorly to enter Mehlis' gland in center of which it forms a loop, the oötype (fig. 5). Mehlis' gland, 0.15–0.17 mm. long, 0.11–0.12 mm. wide, and 0.09–0.11 mm. thick, about twice size of ovary; lies on anterior right side of body, but to left of ovary, closely adherent to dorsal body wall. Its anterior and ventral margins usually project beyond corresponding limits of ovary.

Emerging from near posterior end of Mehlis' gland, uterus has origin on right side of body. It widens rapidly into an ascending uterus, usually so large, 0.04–0.08 mm. in diameter, that, at first sight, it is apt to be mistaken for one of reproductive glands. The resemblance, in many instances, intensified by presence of enormous numbers of spermatozoa which give this portion of uterus a solid appearance. Ascending uterus passes left side of ovary, makes an abrupt loop ventrally and to left, and continues posteriorly as descending uterus along ventral body wall. Diameter of descending uterus varies from that of a completely collapsed uterine wall to a little more than half diameter of ascending uterus. Due to pressure from large seminal vesicle, posterior third of descending uterus usually narrow and displaced to one side of body, whence it turns dorsally to penetrate genital cone at posterior end. Uterine eggs, 0.08 x 0.05 mm., slightly larger than ovary; wholly absent in many specimens and no more than three have been found in a single animal.

Vitellaria in forebody usually extend anteriorly to region about equidistant from acetabulum and oral sucker while, in hindbody, they are confined to two compact and relatively massive ventral columns (fig. 4) which extend posteriorly

for two thirds to four quarters of hindbody length. In some specimens, however, vitellaria extend anterior to acetabulum for a distance less than three times its diameter. Paired vitelline ducts connect vitelline columns, at about middle of their lengths, with a dorsally located vitelline resrvoir (fig. 5), just posterior to and slightly to left of Mehlis' gland. Vitelline reservoir, 0.02–0.04 mm. in diameter, spheroidal in form. Unpaired vitelline duct emerges from dorsal region of reservoir and, running anteriorly, joins oviduct just dorsal to entrance to oötype.

Male Reproductive Organs.—Anterior testis chiefly in anterior left portion of hindbody and entirely to left of both ovary and Mehlis' gland. It might be described as a small segment of a thick spiral, the most posterior portion of which lies the farthest to left of body and most anterior portion, reaching anterior limits of hindbody, closely applied to Mehlis' gland (fig. 7). Although it is misleading to refer to longitudinal and transverse axes, the maximum dimensions of the testis in a generally antero-posterior direction are 0.11–0.12 mm., while the maximum dimensions from right to left are 0.09–0.11 mm., and from ventral to dorsal side, 0.11–0.13 mm.

Posterior testis located, roughly, in posterior half of hindbody. Even more atypical in shape, being elongated and twisted in such a manner that anterior portion lies ventrally on right side of body, while a more elongated projection extends diagonally along left side with posterior termination curving slightly to right and reaching dorsal body wall (fig. 7). Juncture of testicular projections forms an excavated ventral region along which uterus and vas deferens pass. Anteriorly posterior testis contacts the anterior testis, posteriorly it terminates midway between lower limits of vitellaria and posterior end of body. Although testis has more the dimensions of a rope, measurements of entire mass from anterior to posterior limits give figures ranging from 0.15 to 0.25 mm., while maximum breadth (anterior portion) is 0.11–0.13 mm.

Although prolonged search and varied techniques failed to reveal the precise point of emergence, the vas efferens of the anterior testis extends posteriorly from the anterior portion of the testis and meets the vas efferens of the posterior testis midway between the mid-ventral margins of the two testes. The latter vas efferens arises from the excavation at the juncture of the testicular elongations and extends anteriorly to meet the descending vas efferens of the other testis. Vas deferens, extremely variable in diameter, follows dorsal side of descending uterus to communicate with a large seminal vesicle which occupies most of posterior quarter or posterior third of hindbody. Seminal vesicle spheroidal, but a large tube extends dorso-posteriorly from right side, quickly narrowing into an ejaculatory duct (fig. 7), and joins uterus immediately anterior to latter's entrance to genital cone. Seminal reservoir not present.

Habitat.—Intestine of *Ardea herodias hyperonca.*

Vicinity.—Stockton, California.

Date.—October 16, 1933.

Type.—U. S. Nat. Mus., Slide No. 8922.

Paratypes.—College of the Pacific, Stockton, California.

COMPARISONS

Neodiplolstomum orchilongum may be distinguished from all other members of the genus by: (1) the positions and peculiarly elongated and twisted shapes of the testes which can not be described adequately as horseshoe shaped or excavated; (2) the location of Mehlis' gland on the right side of the anterior end of the hindbody between the anterior testis and the ovary, instead of between the testes as in all other members of the genus. The latter distinction is apparently not in accordance with

one of the characteristics of the subfamily Neodiplostominae Dubois, 1932, but inasmuch as the species here described is otherwise a fairly typical member of the group and could not possibly be included in any other subfamily of the Alariidae, its assigned status appears to be justified in the same manner as the manifestly valid inclusion of such forms as *Fibricola cratera* (Barker and Noll, 1915) Dubois, 1932, in the subfamily. The latter genus also possesses a laterally placed Mehlis' gland in the anterior part of the hindbody. The discovery of *Neodiplostomum orchilongum* and of *Neodiplostomum pricei* Krull, 1934, which has the ovary between the testes, suggests that future discoveries of new members of the genus may permit further amplification of taxonomic criteria for the group.

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A FORK-TAILED CERCARIA FROM BERING SEA, WITH A NOTE ON THE MARINE FURCOCERCOUS CERCARIAE HITHERTO DESCRIBED

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Our scanty knowledge of marine furcocercous cercariae may render the following note of interest. Through the kindness of Dr. Martin W. Johnson, of the Scripps Institution of Oceanography, I have received 33 specimens preserved in formalin of a fork-tailed cercaria collected by Dr. Lyman Phifer of the University of Washington, in Bering Sea and Strait, to both of whom my thanks are due for this courtesy. For the privileges of the Institution I am indebted to its director, Dr. T. Wayland Vaughan.

All of the specimens were taken in vertical hauls of the tow net from a depth of 25 m. between latitude 57° 01′ and 66° 15′ N. and longitude 168° 01′ and 172° 19′ W., the depth of water at the points of collection ranging from about 25 to 40 m. Two of them were taken within 3 or 4 km. of St. Paul's Island, while the remainder came from points between 15 and 65 km. distant from the nearest land. The 33 specimens were found in 11 out of 102 collections examined from this area.

The average measurements in μ of nine specimens are: Length 403, tail stem 69, furca 82, oral sucker 85, acetabulum 90.

The form of the larva and its structural details, so far as ascertain-

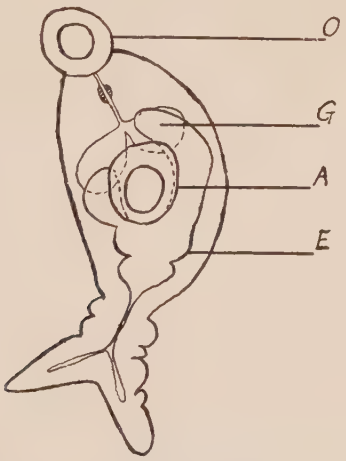

Fig. 1. A fork-tailed cercaria from Bering Sea. Outlines by camera ×135. Details free hand. A—Acetabulum; E—Excretory bladder; G—Gut; O—Oral sucker.

able, are shown in figure 1, which shows it to belong to the eyeless and spineless pharyngeal longifurcate forms as defined by Miller (1926).

Thus far there have been described to my knowledge twelve marine furcocercous cercariae, at least three of which are of doubtful identity.

The cercaria described by Odhner (1911), which he found in an aquarium at Kristineberg, Sweden, together with *Nucula nucleus* and *Syndosmya alba,* and which he considers "wohl mit Sicherheit" to be the larva of *Haplocladius minor,* may possibly be identical with *Cercaria syndosmyae* of Pelseneer (1906), which he found in *Syndosmya alba,* taken in deep water at Boulogne-sur-mer.

While the proportions of these two cercariae appear to be very different, the facts that they may both have the same host (*Syndosmya alba*), that they both were found in the same general region (the north temperate Atlantic) and that the contractility of these worms renders them notably changeable in size and shape, makes their distinctness from each other somewhat uncertain. Neither Odhner nor Pelseneer state whether their descriptions and figure (of the latter author only) are based on extended or contracted specimens. But Pelseneer's figure certainly represents an extended specimen and both he and Odhner apparently had living material for study.

Bucephalus cuculus, described by McGrady (1874) from *Ostrea virginica,* is said by Braun (1879–93) to be probably identical with *B. haimeanus* of Lacaze-Duthiers; but McGrady considers the two forms distinct. He gives no measurements, and his description and figure are inadequate for purposes of comparison.

The cercaria described by Haswell (1903) as related to *Bucephalus polymorphus* (V. Baer) is probably not the same species, since the former occurs in marine mussels, the latter in fresh water naiads. The description of figure 32 of Haswell's paper ascribes this larva to "a species of *Echinostomum,*" which of course is a fish of a totally different feather from *Gasterostomum,* the adult of *Bucephalus.*

Bucephalus haimeanus of Lacaze-Duthiers (1854) is probably *not* a *Bucephalus* at all; not, at least, if this author's description of it be correct, for he says (pp. 300–01), "Il ne semble pas douteux que par l'ensemble des ses caractères il ne doive être rapproché de l'animal décrit par Baer." After specifying several differences he concludes (p. 301) "D'après les dessins du *Polymorphus* la bouche serait sub-terminale . . . tandis qu'ici elle est terminale. . . ." It appears therefore from his description that this is not a larva of a *Gasterostomum* but of some distomid worm. Braun (l. c., p. 834), however, lists it as one of the former. In the form of its tail it resembles *Bucephalus* and it is possible that Lacaze-Duthiers is in error regarding the gut.[1] Even if this be so how-

[1] His observations regarding it are supported however by Moore (1875).

ever it can hardly be the same as the *Bucephalus* larva of Haswell, since, apart from the difference of hosts (*Bucephalus haimeanus* in oysters and cockles, *Bucephalus* of Haswell in mussels) and locality (the Mediterranean and the South Pacific), there are at least two important differences of structure between them: Haswell's larva has spines anteriorly and bears two cilia on the anterior end, which features are lacking in *B. haimeanus*.

The *Bucephalus crux,* described by Levinsen in 1881 from the mussel (*Modiolaria discors*) in Greenland, may be the same as *B. haimeanus*, judging from his figure and inadequate description; although the hosts and distribution (as far as known) of the two forms are different.

Morgan (1891) described a fork-tailed cercaria taken in the ocean off Jamaica. His description, based on a single specimen, which was lost in preparation, is too inadequate to allow of any satisfactory comparison with other forms.

This leaves at least eight marine types described thus far, which are definitely distinct, namely: *Bucephalus haimeanus* (Lacaze-Duthiers), *Bucephalus* of Haswell, *Cercaria dichotoma* (Müller),[2] *C. discursata* (Sinitzin), *C. syndosmyae* (Pelseneer), *C. variglandis* (Miller and Northup), and the cercariae of Haswell (1902) and Linton (1915); while, if Odhner's form be distinct, the total is nine.

The form which I have found in the Bering Sea material does not agree with any of these, although approaching *C. syndosmyae* most nearly. The proportions of the tail (base and furca) in Pelseneer's specimens and my own are quite different, the length of the furca in the former being considerably longer relative to the base than in the latter. His species also appears to be larger than mine. However since my measurements were made on preserved material, while his may have been made on living specimens, no great weight can be placed on these comparisons. Pelseneer also describes and figures head glands in his larva which are apparently lacking in my form; but, since fresh specimens were not available to me, I cannot be certain of this. My specimens however were taken in the North Pacific and Bering Strait far north of the range of *Syndosmya,* which is moreover an Atlantic form,[3] so that it seems unlikely that my species is the same as *C. syndosmyae.* In any event the presence of this larva in the North Pacific Ocean, where none have been reported hitherto, is not without interest.

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[2] This cercaria has been credited to Müller (1850) by La Valette St. George (1885). Braun says that Müller on p. 496 has described "Einefreie marine Cercarie mit geringeltem und mit fiederständigen Borsten besetztem Schwanz," but this is evidently different from that figured by St. George. Miller (1926) says that Müller makes no "definite reference to a furcocercous larva."

[3] Fischer (1887) mentions a sub-genus, Iacra (Adams 1856), which occurs in the Pacific and Indian Oceans from Japan to the Red Sea.

The principal animals in the collections in which these cercariae were found were the copepods *Oithona helgolandica, Eucalanus elongatus, Calanus finmarchicus, Calanus* sp. *Pseudocalanus elongatus,* and an occasional *Acartia longiremis.* With these were associated the tunicate, *Oikopleura,* the ctenophore, *Pleurobrachia,* the chaetognath, *Sagitta,* an occasional hydroid, and various larval forms (echinoderms, lamellibranchs, etc.) Whether any of these may serve as host for the cercaria is unknown. However the facts that a closely related form, *Cercaria syndosmyae,* inhabits the lamellibranch, *Syndosmya,* and that its habitat is relatively shallow coastal waters, renders it more likely that some bottom dwelling mollusc serves as host.

The number of specimens collected and their wide distribution in this region indicates that the organism, whatever its host, is a common one.

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NATURAL INFECTION OF AMERICAN HUMAN TRYPANOSOMIASIS IN TWO SPECIES OF CONE-NOSED BUGS, *TRIATOMA PROTRACTA* UHLER AND *TRIATOMA UHLERI* NEIVA, IN THE WESTERN UNITED STATES

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The discovery of a trypanosome in the digestive tract of *Triatoma protracta* Uhler by Kofoid and McCulloch[1] in 1916 proved to be (see Kofoid and Donat;[2] Wood[3]) the first report of the occurrence of the causative organism of American human trypanosomiasis in the United States. The bugs carrying this infection were collected near San Diego, California, in one canyon only, from the nests of wood rats, *Neotoma fuscipes macrotis* Thomas, in 1916, 1933 and 1935. Kofoid and Donat[2] reported the finding of American, so-called Brazilian, trypanosomiasis in the insect vector or cone-nosed bug, *Triatoma protracta,* and its experimental inoculation into the probable reservoir mammal, the wood rat, *Neotoma fuscipes macrotis.* The following mammals (see Wood[3]) have been experimentally inoculated and trypanosomes recovered in the peripheral blood after the incubation period characteristic of the host species: albino Norway rats, albino mice, Virginia opossums, rhesus monkeys (*Macacus rhesus* Desmarest), San Diego wood rats (*Neotoma fuscipes macrotis* Thomas), Portola wood rats (*N. f. annectans* Elliot), and five species of white-footed mice (*Peromyscus californicus californicus* [Gambel], *P. C. insignis* Rhoads, *P. eremicus fraterculus* [Miller], *P. maniculatus gambeli* [Baird], *P. truei gilberti* [Allen]). It is highly probable that the armadillo will be found to serve as a reservoir host in the U. S. A. (Texas), as in Brazil. Subsequent investigations now enable us to extend the range of infected insect vectors into Arizona and to add another species, *Triatoma uhleri,* to the insect vectors of this trypanosomiasis in the United States.

We report in this paper the discovery of *Trypanosoma cruzi* Chagas, the etiological factor of American human trypanosomiasis, in a second

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[1] Kofoid, C. A., and McCulloch, I. 1916. On *Trypanosoma triatomae,* a new flagellate from a hemipteran bug from the nests of the wood rat, *Neotoma fuscipes.* Univ. Calif. Publ. Zool., 16: 113.

[2] Kofoid, C. A., and Donat, F. 1933. South American trypanosomiasis of the human type—occurrence in mammals in the United States. Cal. and West. Med., 38: 245.

[3] Wood, Fae D. 1934. Natural and experimental infection of *Triatoma protracta* Uhler and mammals in California with American human trypanosomiasis. Amer. Jour. Trop. Med., 14: 497.

species of cone-nosed bug, *Triatoma uhleri* Neiva, collected from November, 1934, to June, 1935, in the vicinity of Tucson, Arizona. We are indebted to Dr. C. T. Vorhies and Dr. L. P. Werhle, of the University of Arizona, for the supply of bugs sent to our laboratories from Arizona, and to Mrs. Orville Larsen and Mr. H. E. Weisner for the information concerning the conditions under which these bugs were collected. We have received, in all, nine shipments, with a total of seventy-nine specimens of *Triatoma uhleri* and two of *T. protracta.* Seven of the seventy-nine specimens of *T. uhleri,* or nine per cent, were infected, discharging in their feces large numbers of *Trypanosoma cruzi* in the metacyclic, infective stage. No trypanosomes were revealed in the feces of the two specimens of *T. protracta* from this locality, though previously found in this species in California.

All four specimens of one shipment of *T. uhleri* were infected. These were collected in the vicinity of Tucson, Arizona, from the nest of a wood rat and from the pile of lumber in which the nest had been constructed.

One large nymph of *Triatoma uhleri* caught by Mr. Weisner in a bed was engorged with blood, but it could not be determined whether or not the blood in the stomach of the bug was of human origin. This bug harbored the metacyclic stage of *Trypanosoma cruzi.*

One of fourteen *Triatoma uhleri* collected by Mrs. Larsen in her home proved to be infected with *Trypanosoma cruzi.* A later shipment of twenty-one specimens from the same source contained one infected bug. Mrs. Larsen stated that bugs of this species had bitten her on several occasions. As is often the case, she first experienced considerable local reaction, followed, after repeated bites, by a general systemic reaction which made it necessary for her to leave the vicinity of her home in order to recuperate. Her distress was caused, presumably, by the salivary secretions of the bug; there is no evidence that the reaction was in any way associated with trypanosome infection. The increase in local and systemic reaction which accompanied the earlier consecutive bites was probably caused by sensitization, the reaction becoming most pronounced when maximum sensitivity was reached. Subsequent bites would then result in desensitization, the reaction becoming less and less severe.

The trypanosome infection is transmitted to man by contamination. The infective stages of the trypanosome are discharged from the rectum of the bug immediately after feeding, or shortly thereafter. Presumably, should these infective stages of the trypanosome be rubbed into the lesion made by the bug or into lesions made by scratching, infection of the bitten person might ensue. In laboratory animals experimental infection has actually been induced by intraperitoneal injection of the rectal con-

tents of the bug, by placing the rectal discharge of the bug in the axilla of young mice, on the conjunctiva, into the mouth, by feeding the infective bug to the animal, or, presumably, by rubbing these contents into the lesion caused by the bite. In all of these cases there is either penetration of a mucous membrane, or entrance by a lesion through the skin or through it in a susceptible region such as the axilla.

The bugs collected by Mrs. Larsen were taken in various rooms of her home, usually after 7:00 P. M., a large number being caught in the sleeping porch between midnight and 3:00 A. M. The house has an uncemented rock foundation, so constructed as to give access to small animals. Mrs. Larsen believes a wood rat has its nest under the house. Such nests are known to be a much favored breeding place for *Triatoma*, and when located in the immediate vicinity of a house would act as a reservoir for the bugs. The bugs might enter the house through cracks under doors, through open doors and windows, or from under the house through cracks around the baseboard.

It is Mrs. Larsen's observation that *Triatoma uhleri* is most active at night and avoids the light. This is an indication that this species is negatively phototropic, as is *T. protracta* (Wood[8]). Members of the Larsen family have been bitten only while sleeping. The bugs migrate actively, gaining access to the bed or bedding after the bed is occupied, engorging with blood, and then retiring to a suitable hiding place.

The feces from two of the bugs in the shipment of four taken from the wood rat nest by Mr. Weisner were inoculated intraperitoneally into a twenty-one-day-old white-footed mouse, *Peromyscus californicus insignis* Rhoads. These mice may be trapped in the vicinity of wood rat nests. Trypanosomes were first observed in the peripheral blood of this mouse seven days after inoculation. The peak of the infection was reached twenty-eight days after inoculation, when forty to fifty trypanosomes were found in one microscopic field, when observed with a 4 mm. objective and 10X oculars, in a fresh smear of peripheral blood prepared by placing a small drop of blood from the tail of the mouse on a microscope slide and allowing this to spread under the pressure of an 18 mm. round coverglass.

Thirty-seven days after inoculation the number of trypanosomes in the peripheral blood had markedly decreased. The mouse was then sacrificed and impression smears made of the heart muscle. These smears revealed large numbers of leishmaniform bodies, a diagnostic feature of *Trypanosoma cruzi* in the mammalian host.

We have examined the California strain of *Trypanosoma cruzi* in the blood of young *Peromyscus californicus insignis* and albino mice on several occasions and have also observed a virulent strain of *T. cruzi*

from South America in the blood of the white mouse. It is of interest to note that the one mammalian infection with the Arizona strain of *T. cruzi* gave results (40–50 in a field) resembling more closely the often observed heavy infection of the virulent South American strain than that produced in the white mouse by the strain of *T. cruzi* from California, which Wood[3] has shown to be relatively non-virulent. The albino mouse inoculated with the South American strain showed from forty to sixty organisms in a microscopic field under the same method of preparation and same magnification as described above. Trypanosomes of the California strain have never been observed by us in numbers greater than two in a microscopic field under the same conditions. In one experiment a young *P. californicus insignis* was inoculated intraperitoneally with the California strain in the fecal material of two infected *Triatoma protracta* for five consecutive days, using ten bugs in all. This was an attempt to produce a heavy infection, but at the peak of the infection thus established never more than two trypanosomes—and even this rarely—were observed in a microscopic field prepared as above. Further experimentation is in progress to determine the comparative virulence of these three strains of *T. cruzi.*

Human infection by *Trypanosoma cruzi* is unlikely in California, as has been pointed out by Kofoid and Donat.[2] The factors militating against human infection are (1) the limitation of the wood rat and other natural mammalian reservoirs to wooded canyons and hillsides and, in general, to the uninhabited chaparral belt; (2) the fact that not all bugs and not all wood rats are infected; (3) the mild, non-virulent nature of the California strain of *T. cruzi*; (4) the small numbers of trypanosomes in the peripheral blood of the natural reservoir mammals and the relatively short time of their abundance, both tending to limit the infection of the insect vector; and (5) the practical limitation of the mode of human infection to contamination by rubbing the feces of the bug into the lesion in the skin caused by the bite.

Certain factors favor human infection, such as (1) the tendency of wood rats to enter and build nests in and about houses; (2) the visitation of houses by the insect vector *Triatoma*; and (3) the positive thermotropic response of *Triatoma* to warmth, which leads them to enter warm houses and beds and to be attracted by the warmth of the body and feed thereon. It is obvious that the conditions under which the infected *Triatoma uhleri* sent to us from Arizona were collected considerably increase the possibility of human infection. The extension of the known range of infected bugs and the findings of another infected species of *Triatoma* also add to the hazard of human infection in the Pacific Southwest.

SUMMARY

1. Natural infection of cone-nosed bugs, *Triatoma protracta,* with *Trypanosoma cruzi* was first reported in the United States in 1916.

2. A new species of cone-nosed bug, *Triatoma uhleri,* has been discovered to be naturally infected with *Trypanosoma cruzi.*

3. A new area, the vicinity of Tucson, Arizona, has been discovered as a region of infected insect vectors.

4. Infected bugs have been found in this region in houses and in beds.

AGE AS A FACTOR IN THE DEVELOPMENT OF RESISTANCE OF THE CHICKEN TO THE EFFECTS OF THE PROTOZOAN PARASITE, *EIMERIA TENELLA**†

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Age has for many years been recognized as an important factor in the resistance of animals to the development and effects of their parasites. The work of Ransom (1921) showed that young chickens were quite susceptible to infection with *Syngamus trachea* and were seriously affected by the infection whereas older chickens were refractory to infection. Herrick (1925) showed that the chicken became increasingly a more unsuitable host for the development of *Ascaridia lineata* as it increased in age. Johnson (1923) was of the opinion that age was an important factor in the resistance of chickens to coccidiosis and in his later work (1928) states, "Young fowls infected with a large number for the first infection regularly die with the disease. This is more especially true of growing stock. Older fowls may show considerable bleeding and recover. . . ." Tyzzer (1932) infected chickens with *E. tenella* when 6, 33, 50, and 71 days old. The resultant mortality was respectively 50, 37.5, 50, and 100 per cent. He explained the greater susceptibility of the older chickens on a mechanical rather than a humoral basis. Mayhew (1934) concludes from his work that age is not a factor in the development of resistance of chickens to coccidiosis. Stafseth (1931) pointed out that older chickens were infectable but were more resistant to the effects of the parasites than were younger chickens. Many references might be cited, but from these studies there is evidently a difference of opinion regarding the importance of age as a factor in the resistance of the chicken to coccidiosis. In order to obtain further evidence on this point chickens of various ages kept under carefully controlled conditions were infected and studied throughout the course of the infection.

MATERIAL AND METHODS

The chickens used in these experiments were Single Comb White Leghorns furnished by the Department of Poultry Husbandry of the

* This work was supported in part by grants from the Wisconsin Alumni Research Corporation and the University of Wisconsin Research Fund.
† Published with the permission of the Director of the Wisconsin Agricultural Experiment Station.

University of Wisconsin. The measures of resistance used were the change in the erythrocyte count and the mortality produced as the result of infection. The erythrocyte counts were made by means of a standard hemocytometer just previous to infection and at the same time daily thereafter until the erythrocyte count approximated the normal following infection.

The oocysts were from a pure line of *Eimeria tenella* developed from a single oocyst and were sporulated in 2.5 per cent potassium dichromate; they were administered by means of a pipette into the crop of the chickens. The number of oocysts administered to the different aged groups was varied according to the age of the chickens. The dosage, "N," represents approximately 200,000 sporulated oocysts in 1 m.l. of suspension. Uninfected control chickens were always kept in the cages with those infected except for a 24-hour period just succeeding infection. The feed, care, and precautions to prevent accidental infection were the same as that regularly given our experimental chickens (Herrick and Ott, 1936).

In order to reduce the importance of climatic conditions, number and viability of oocysts given and other factors, the 14 day old group was infected with the same suspension of oocysts and at the same time as the group 10 months old. Likewise, the group 30 days old was infected with the 15 months old group. The other infections were not made simultaneously, but the viability of the culture of oocysts used was constantly being checked by the mortality produced in chickens used in other experiments, and so far as could be determined there was no change in the mortality produced by a given number of oocysts in various groups of thirty day old chickens used during the course of these experiments. It is believed, therefore, that any difference in resistance to infection shown by the various aged groups was not due to any change in viability of the oocysts used.

PRESENTATION OF DATA

By referring to Fig. 1, which shows graphically the change in erythrocyte counts of the various groups, it will be noted that in most cases the red blood cell count was approximately normal until the fifth day after infection when there was a sharp drop. The decrease was more pronounced on the sixth with the minimum count occurring on the seventh day in most cases. Following the minimum count the erythrocytes increased rapidly and returned to normal in approximately two weeks.

The group of chickens infected when 14 days old consisted of 20 chickens approximately equal as to sex. As previously stated, they were infected from the same suspension of oocysts, and at the same time as the group 10 months old. The number of oocysts received was, however,

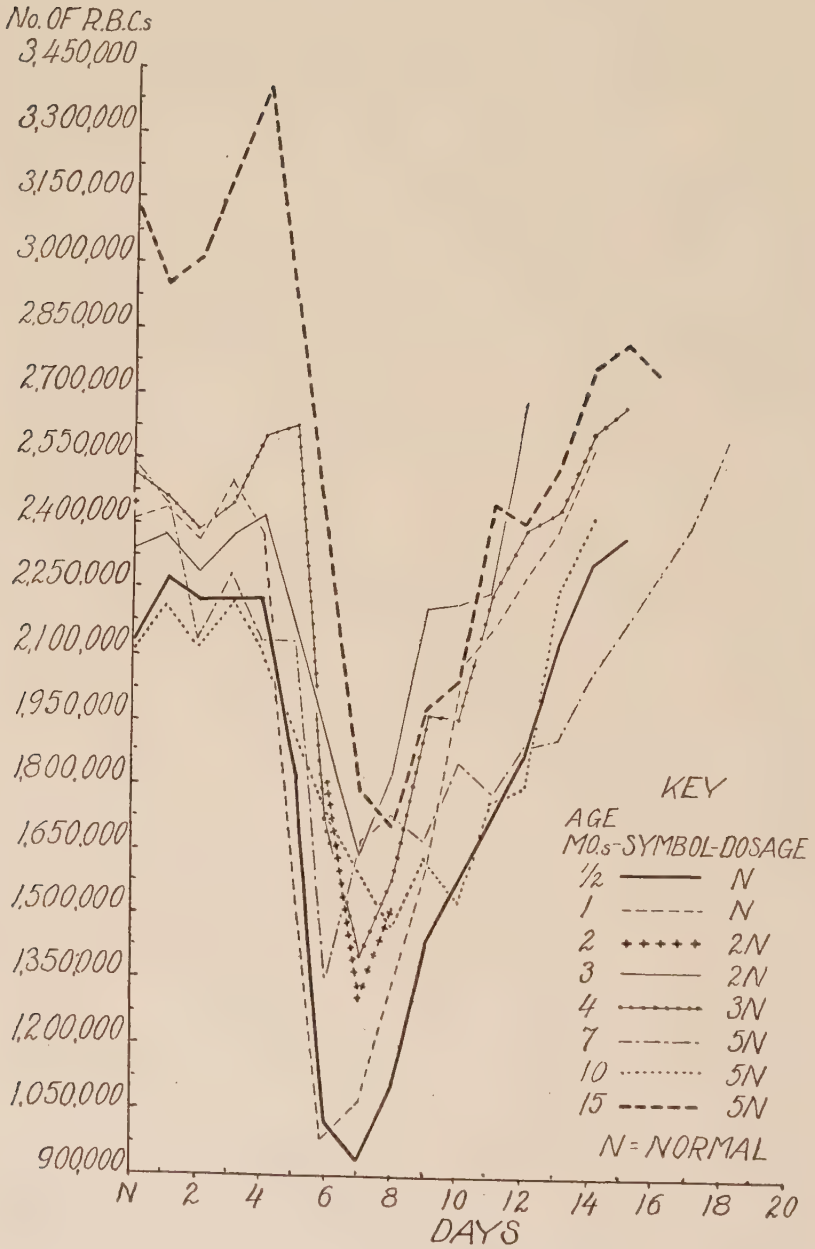

FIG. 1. Erythrocyte counts of chickens infected with *Eimeria tenella*.

"N," or one-fifth that given the latter group. The erythrocyte count for the 14-day group at time of infection was 2,141,000, and remained at approximately that level until the fifth day. Beginning on the fifth day there was a marked decrease which continued until the seventh day when a minimum count of 937,900 was reached, making an average decrease of 56.2 per cent. The resultant mortality from the infection was 50 per cent. The comparable infection given the 10 months old chickens caused the erythrocyte count to drop from the normal of 2,100,000 to a minimum of 1,472,500 on the eighth day, a decrease of only 29 per cent. There was no mortality in this group. The rather low normal count was probably the result of heavy egg production which was approximately 65 per cent.

Although this group suffered little from the infection, symptoms were apparent. There was considerable hemorrhage and egg production ceased on the fifth day except for one egg which was laid on the sixth. A control hen which has been kept with this group since coming from the incubator maintained her normal erythrocyte count and egg production throughout the experiment. When autopsied at the termination of the experiment she was found to be free from oocysts while the infected hens all harbored oocysts in the tissues of the cecal pouches. The absence of all signs of infection in the control hen would indicate that the greater resistance of the 10-months chickens over those 14 days old was not due to a previous infection.

The 15 months old group consisted of only three cocks and one hen which had served as controls for another experiment. That they had not previously become infected is evidenced by the negative findings in other controls kept with them during their 15 months in the laboratory. This group was infected simultaneously with chickens one month old. The number of oocysts administered was, however, five times that given to the younger group. The normal erythrocyte count for these chickens when infected (average of the two days) was 3,105,000. Following the administration of oocysts the blood count increased to 3,425,000 on the fourth day (see Fig. 1). The count decreased rapidly on the fifth and sixth days and then more gradually until a minimum count of 1,722,000 was reached on the eighth day. The decrease in number of erythrocytes of 1,383,000 (44.5 per cent) was approximately equal to that sustained by the chicken 14 days old, and twice the decrease that occurred in count of the group 10 months old. Although the decrease in blood count for the 15 months old chickens was great, the minimum count was comparatively high (Fig. 1), and they seemed to suffer no great inconvenience from the infection. No deaths occurred in this group.

The 61 animals which made up the group infected when 30 days old were approximately equally divided as to sex. When infected with the

group 15 months old their average erythrocyte count was 2,405,000 and remained at that level until the fifth day when it decreased sharply. The minimum of 949,000 occurred on the sixth day, earlier than in any other group. The decrease in the number of erythrocytes was 60.5 per cent and the resultant mortality was 72.1 per cent. The minimum which resulted from the infection in this group was essentially the same as for the chickens infected when 14 days old, but the mortality resulting from infection was considerably higher than in the younger group (14 days). The very low minimum count and the mortality caused by coccidiosis in this group shows that they were much more susceptible than were either the 10 or 15 months old groups. The seeming high susceptibility of chickens of this age will be discussed later.

The 42 chickens infected when two months old were approximately equally divided as to sex. They were given twice the number of oocysts as the 30 day old group, but were not infected until 19 days later. Since the oocysts were kept under quite uniform conditions, and since they retain their viability for such long periods, it seems probable that this group received an infection comparable to that received by the one and fifteen months old groups. If the oocysts did become reduced in viability, the resulting infection would tend to be less severe and thus erroneously indicate the group to be more resistant. The chickens receiving their infection when 60 days old had a normal erythrocyte count of 2,441,000. As it was impossible to make daily counts on this group, counts were made in the 6th, 7th, and 8th days following infection. The minimum count of 1,323,100 was reached on the 7th day, a percentage decrease of 45.8. The decrease was approximately equal to that in older groups, but the rather high minimum count is due to the fact that all deaths but one occurred suddenly, just before the blood counts were made. In no other case did this condition exist. Had the counts been made an hour sooner, counts would have been made on chickens soon to die with a low erythrocyte count. The minimum count as it is given represents except in one case the counts of survivors. The mortality in this group was 54.7 per cent, which indicates that the chickens infected when 2 months old were more susceptible to effects of coccidiosis than were older chickens.

The chickens infected when seven months old were all males, normal in appearance, and no oocysts could be demonstrated in their cecal droppings. Controls examined from this group were found to harbor no oocysts in the tissues of their cecal pouches. It is believed, therefore, that these animals had not been previously infected. Their erythrocyte count at time of infection was 2,539,000. The minimum count of 1,350,000 occurred on the sixth day, a decrease of 46.8 per cent. It was evident on the sixth day that one chicken was much more seriously af-

fected than were the others. The erythrocyte count for this animal was only 1,140,000, whereas the average for the other four was 1,560,000. The badly affected animal died within two hours after the blood count was made, making the mortality in this group resulting from coccidiosis 20 per cent. Since the minimum erythrocyte count for the survivors of this group (7 months) did not go below 1,560,000, it seems that their resistance was approximately equal to that of chickens three months old and older. The mortality, however, shows that certain individuals at least are quite susceptible even at the advanced age of seven months.

The group of chickens infected at the age of four months consisted of three males and two females. The oocysts used to infect this group were from the same pure line and were handled in the same manner as the oocysts used to infect the other groups, but were from a different culture. By determining the death rate in thirty day old chickens when infected by oocysts from this culture, it is evident that this group, infected when four months of age, received a number of oocysts comparable to that given other groups. The normal erythrocyte count for these chickens at the time of infection was 2,518,500. The minimum count 1,380,000 occurred on the seventh day with a decrease in number of blood cells of 45.6 per cent. Although the loss in erythrocytes was great, the number of cells remaining was sufficient ti carry on metabolism and make it possible for all animals in this group to live, indicating that they were approximately as resistant as chickens infected when seven, ten, or fifteen months of age.

The group of chickens infected when three months of age consisted of five females and four males. The erythrocyte count, which at the time of infection was 2,360,000, declined to a minimum of 1,498,000 on the seventh day. This minimum count, which represented a decrease of only 36.1 per cent, compared very favorably with that of the older groups; in fact, it was greater than the minimum of all other groups except for those infected when 15 months old. It seems, therefore, that the chickens infected when three months old were much more resistant to the effects of coccidial infection than were chickens infected when 14, 30, or 60 days old and were approximately as resistant as chickens which were infected when considerably older (4, 7, 10, and 15 months).

DISCUSSION

It is evident from the data presented that in regard to the degree of resistance exhibited by the various groups of chickens, they fall into two classes: (1) those infected when not over two months old in which there occurred a very low minimum erythrocyte count and a high mortality, and (2) those infected when three months old or older which maintained a high minimum erythrocyte count during the infection and

in which there was practically no mortality. The mortality rate for the 123 chickens of the former susceptible class was 62.6 per cent as compared to 3.6 per cent for the older more resistant class. The group infected when thirty days old suffered a mortality of 72.1 per cent which was considerably above that for the groups infected when 14 or 60 days of age. (See table 1.) It will be noticed also that the minimum erythrocyte count for this group (30 days) occurred on the sixth day following infection which was earlier than for any other group except the one infected when seven months old. Of the resistant class the group infected when seven months old was the only one in which any mortality occurred. The erythrocyte count of all the members of this group reached the minimum count on the sixth day but the count of the one that died was much lower than the others of the group, which indicates that some chickens even of the advanced age are very susceptible to coccidiosis. The resistance of the group as a whole except for the one individual, compared very favorably with other groups of the resistant class. It will be noted that the erythrocyte counts of the group infected when seven months old and also those infected when fifteen months old were slow in returning to normal following infection. It seems probable that this was due in part at least to the failure of the males to obtain sufficient food.

When reared in-doors, White Leghorn males develop enormous combs but when normal would reach their heads through the 2″ x 12″ gratings of the cages to obtain food. When reduced in vitality by coccidiosis, however, they would at times go hungry rather than reach their heads through the gratings. When the feed dishes were so changed that food could be more easily obtained food consumption increased and the erythrocyte counts rapidly returned to normal (see table 1).

It would seem from the data presented that death from coccidiosis is rare if the infection occurs after the chickens have reached the age of three months. This is evidently true when chickens are given the number of viable oocysts used in these experiments. When, however, the number of oocysts was increased sufficiently, as was the case in experiments to study the effects of coccidia (to be presented later), the death rate of chickens six or seven months old was as high as that of the young chickens reported here. Such heavy doses were not used in these studies for in such cases a mortality of over 99 per cent occurred in the younger groups thus terminating the experiment.

It is interesting to note that the chickens used in the experiment reported here developed a resistance to the effects of *Eimeria tenella,* a tissue invading protozoan parasite at approximately the same age that they became resistant to *Ascaridia lineata* (Herrick, *loc. cit.*) a nematode parasite that invades the tissues for only a short period of time and

TABLE 1.—*Showing the Change in Erythrocyte Count and Mortality in Chickens of Various Ages Resulting from an Infection with Eimeria tenella*

Age in months ..	1/2	1	2	3	4	7	10	15
No. of animals ...	20	61	42	9	5	5	5	4
Date of infection	6–5–34	8–23–34	9–11–34	4–1–34	12–14–33	3–12–34	6–5–34	8–23–34
Dosage	N	N	2N	2N	3N	5N	5N	5N
Normal r.b.c.	2,141,000	2,405,000	2,441,000	2,360,000	2,518,500	2,539,000	2,100,000	3,105,000
Minimum r.b.c. ..	937,900	949,000	1,323,100	1,498,000	1,380,000	1,350,000	1,472,500	1,722,000
Decrease r.b.c. ...	1,203,100	1,456,000	1,117,900	862,000	1,138,500	1,189,000	627,500	1,383,000
% Dec. r.b.c.	56.2	60.5	45.8	36.1	45.6	46.8	29.0	44.5
No. dead	10	44	23	0	0	1	0	0
% Mortality	50	72.1	54.7	0	0	20	0	0

later lives unattached in the lumen of the intestinal tract. Why the resistance should develop at this time is not known. Ackert (1934) pointed out that something relative to the growth inhibiting substance described by Carrel and Ebeling (1922) might be elaborated by the chicken when it reaches the age of about three months. Whether or not this is the complete answer remains for further experimentation. It seems, however, that the condition or conditions that make the chicken more resistant develops rather rapidly and is quite effective in protecting the chicken against the effects of at least some of its parasites.

SUMMARY AND CONCLUSION

Eight groups of 151 chickens ranging in age from 2 weeks to 15 months were infected with the protozoan parasite, *Eimeria tenella*. Erythrocyte counts were made before infection and daily thereafter until the blood count had returned to normal. From the data presented it seems apparent that: (1) chickens of all ages up to and including 15 months are susceptible to infection with the parasite *Eimeria tenella* and show symptoms of acute coccidiosis following infection, and (2) chickens infected when three months old or older are considerably more resistant to the effects of *E. tenella* than are chickens infected when not over two months old.

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MEDIOGONIMUS OVILACUS, N. G., N. SP.*

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Our attention was directed to this new trematode when performing an autopsy on a *Microtus pennsylvanicus pennsylvanicus,* in February, 1931. This *Microtus* yielded five large specimens. On July 26, 1933, from an adjacent area one microtus was found infected with 60 specimens ranging from small immature to old adults, but none were as large as in host number one. In both cases the trematodes were lodged in the left dorsal lobe of the liver. In case ♯ 1 the worms were clearly visible beneath the liver capsule. In case ♯ 2, all worms were crowded into a heavy walled, fibrous-sheathed liver tubule. On removal from the liver the flukes appeared deep red in color, pyriform in shape, with a clear anterior end. The anterior end contracts greatly when fixed, which accounts for the compact appearance in the plate.

Microtus trapped in other areas than the immediate vicinity of the range of host ♯ 1 and ♯ 2 have all been negative. Of 43 specimens of *Microtus* trapped, only the 2 have been infected. Many shrews and specimens of *Peromyscus* were caught on the range, but none were infected with this liver fluke.

An attempt has been made to find the molluscan part of the life cycle. All types of land snails were secured from very small to the large *Polygyra.* No cercariae were found that would furnish the specifications called for by the family Plagiorchidae. *Amnicola,* which serves as the host for *Prosthogonimus,* was not secured from the nearby sewage-polluted river. Dragon flies with cysts were fed to laboratory-raised *Microtus* without result.

Mediogonimus n. g.

Generic diagnoses: Body completely covered with spines. Oral sucker and ventral sucker of approximately equal size. Pharynx muscular and large. Oesophagus short. Intestine branches in anterior 1/5 of body; crura reach nearly to posterior end. Vitellaria extracrural, extending from level of intestinal fork to middle of testes. Uterine coils extend to lateral edges but not pre-acetabular. Ovary greatly lobed, dorsal in position, slightly overlapping ventral sucker and at same level. Cirrus sac straight or slightly convoluted. Testes slightly lobed and of approximately same size. Genital pore immediately posterior to pharynx and median in position, anterior to intestinal fork.

Type of genus: *Mediogonimus ovilacus.*

Host: *Microtus pennsylvanicus pennsylvanicus.*

Location: liver.

Locality: Ann Arbor, Michigan.

* Contribution from the Department of Zoology of the University of Michigan.

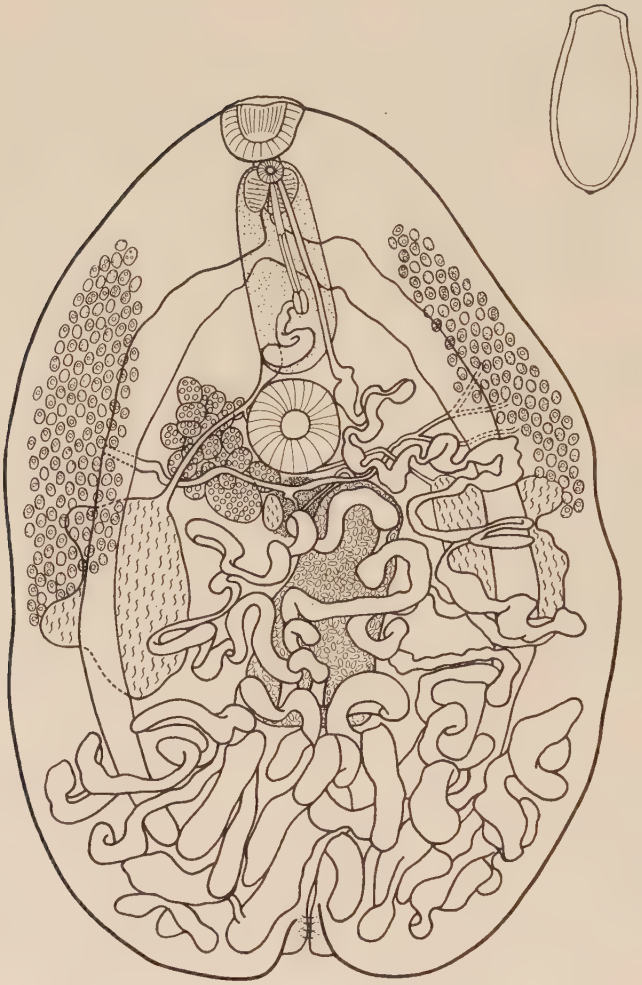

FIG. 1. *Mediogonimus ovilacus*

Mediogonimus ovilacus n. sp.

Species description: Body pyriform, having distinct indentation at excretory pore. Total length 2.31 mm., maximum width 1.43 mm.; average ratio of body length to width, 2:1. Dense cuticular spines completely cover body. Oral sucker .204 mm. long and .258 mm. wide. Ventral sucker .286 mm. long and .272 mm. wide, situated in anterior 2/5 of the body. Large, spherical pharynx continuous with oral sucker and .115 mm. long by .122 mm. wide. Oesophagus short, bifurcating into intestinal crura midway between oral and ventral suckers. Crura extend to posterior end of body. Genital pore posterior and adjacent to pharynx, median in position, .068 mm. anterior to intestinal fork. Deeply staining cells surround aperture. Testes globular and slightly lobed, lying at same level, posterior to ovary. Both testes approximately same size, .544 mm. long, .258 mm. wide. Seminal vesicle wide and coiled; cirrus .204 mm. long and only slightly curved. Cirrus pouch oval, .476 mm. long, .204 mm. wide, extending from genital

pore to ventral sucker; .326 mm. long, .258 mm. wide. Seminal receptacle close behind ovary, directly posterior to acetabulum. Mehlis gland large. Laurer's canal present. Uterus makes many coils, containing few eggs, and then broadens in middle of body into a large and conspicuous "egg reservoir." Reservoir densely packed with eggs. Uterus voluminous and extracrural, no preacetabular coils. Vitellaria extend from level of intestinal fork to near the posterior end of testes; follicles numerous and evenly spaced. Common vitelline duct crosses body just anterior to testes. Eggs .32 mm. x .013 mm., oval, medium brown and capped; a posterior spine may or may not be present. Excretory bladder thick and Y-shaped. It empties at posterior end through a large duct.

Host: *Microtus pennsylvanicus pennsylvanicus.*
Location: liver.
Locality: Ann Arbor, Michigan.
Type specimens: U. S. N. M. No.

Discussion: The genus *Mediogonimus* is included in the Family Plagiorchiidae, subfamily Prosthogoniminae as defined by Travassos, 1928, since it possesses every family characteristic. Two genera, *Prosthogonimus* and *Schistogonimus,* under the subfamily Prosthogoniminae are listed. *Mediogonimus* differs sharply from *Prosthogonimus* by having a median genital pore posterior and adjacent to the pharynx, a larger cirrus sac, a swollen uterus segment termed egg reservoir; the genital pore of *Prosthogonimus* is either marginal or to the right or left of the median line. *Mediogonimus* may be distinguished from *Schistogonimus* by having genital pores very close together and in a characteristic median position, an extracrural and diffuse uterus; whereas *Schistogonimus* has the male and female genital openings some distance apart, an intercrural and centralized uterus.

Acknowledgements are due to C. R. Housley for his work on this problem during the summer of 1933.

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ORNITHODOROS HERMSI WHEELER AS A VECTOR OF RELAPSING FEVER IN CALIFORNIA

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The first two cases of relapsing fever were reported from California in 1922 by Briggs at Polaris in Nevada County not far from Lake Tahoe and at an elevation of about 5800 feet. A total of 95 cases has been recorded by the California State Department of Public Health since that time. Table 1 shows the distribution of cases by years and months. It will be noted that the cases occur principally during the months of June, July and August. No doubt some cases are not reported, and on the other hand with better knowledge concerning the disease, particularly recognition through laboratory diagnosis, more cases come to the reporting stage. With increased occupancy of cottages in infected mountain localities an increase in the number of cases might be expected. Be that as it may, 46 of the 90 cases reported for California have occurred at Big Bear Lake in San Bernardino County and 26 at Lake Tahoe in Placer and Eldorado counties. At both of these lakes there is a number of popular summer resorts and many privately owned summer cottages. The remaining 23 cases have occurred in widely scattered localities; however, practically all of them along a line connecting the two main foci, and at elevations ranging from about 5000 to 8000 feet.

While conducting field investigations during the summer of 1932 at Packer Lake (Sierra County), the junior author accidentally smeared his fingers with blood from a chickaree or red tree squirrel (*Sciurus douglasii*) and there resulted a typical case of relapsing fever with blood smears positive for spirochaetes (Legge, 1933). Blood smears from these squirrels as well as those from chipmunks (*Eutamias* sp.) proved positive for spirochaetes and subsequent laboratory inoculations of blood from these rodents into white mice were also positive for spirochaetes. This, as well as other work done by Wynns and Beck (1935), gave positive evidence that rodents, among them the chickaree squirrel and chipmunk, constitute reservoir animals for the causative organisms of relapsing fever.

Historically spirochaetal relapsing fever is known to be transmitted by ticks and by lice. Since conditions under which relapsing fever in California was contracted did not indicate the presence of lice, it was believed long ago that the vector in this state would prove to be a species of tick, particularly a member of the genus *Ornithodoros,* hence our early searches for these arthropods. Our first success in locating ticks

TABLE 1.—*Relapsing Fever in California*
Cases by months of onset

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1921 .						2							2
1922 .													0
1923 .									1				1
1924 .													0
1925 .									1				1
1926 .													0
1927 .						1							1
1928 .						1							1
1929 .													0
1930 .							3		1				4
1931 .						1	9	2					12
1932 .		1		1		3	5	5	1				16
1933 .		1				6	6	6					19
1934 .					1	2	6	2					11
1935 .						1	1	3	2	2			9
Totals		2		1	1	17	30	18	6	2			77

There are 13 cases not included in the table as follows:
1927. 1 case, month unknown.
1935. 11 cases, months unknown.
1 case, the year unknown.

belonging to this genus, so far as relapsing fever foci are concerned, was during the summer of 1931 at Lake Tahoe. In 1933 we received several specimens of the same species (then undescribed) from Big Bear Lake and during the summer of 1934 numerous specimens of this tick were taken, also at Big Bear Lake in rodent nesting material, in cottages and cabins in which cases of relapsing fever had occurred.

Prior to testing this undescribed species of *Ornithodoros* considerable experimental work was done in our laboratory with *Ornithodoros coriaceus,* the pajaroello tick, a widely distributed species in California, although not present in the mountain ranges where relapsing fever occurs. In this experimental work spirochaete strain No. 334 (Hooper Foundation) was used. This strain was originally discovered in the blood of chipmunks (*Eutamias* sp.). We used white mice and guinea pigs in our transmission tests, all tests proving negative (Herms and Wheeler, 1935).

The first test with the new species of tick, conducted at the Hooper Foundation (Wheeler, Herms & Meyer, 1935), took place as follows: on September 23, 1934, six specimens of last stage nymphal ticks taken at Big Bear Lake, August 17, and September 13, 1934, were placed on the shaven abdomen of a Macacairus monkey. The ticks fed to repletion in from 19 to 31 minutes and detached voluntarily with no trace of coxal fluids or fecal material apparent on either the skin of the monkey or the ventral surface of the ticks. Coxal fluids are mentioned here because it has been believed that these fluids are concerned in the transmission of the spirochaetes. On October 9, 1934 (16 days after the tick bites) the monkey developed characteristic symptoms of relapsing fever and spirochaetes were present in blood smears taken from the ear of this

animal. A relapse occurred on October 23, 1934 (14 days after the first attack) and again spirochaetes were demonstrated in the blood. These six ticks molted after this feeding and each was fed on a white mouse to determine individual infectiveness. Two only proved infectious. The tests on mice were, of course, much delayed because of the fact that an interval of several weeks elapsed between feedings—*i.e.*, positive results with mice in this original test did not come to light until the following March and April.

On February 1, 1935, one nymphal tick taken on August 17, 1934, from a chipmunk's nest in the G. cottage at Big Bear Lake and not having previously fed on any experimental laboratory animal was placed on the shaven abdomen of a normal white mouse. The tick attached immediately and fed to repletion in 33 minutes, detaching of its own accord. Here again no coxal fluid was evident. The body of the tick was greatly distended as is usually the case after feeding to repletion on blood, giving it the appearance of a "strawberry seed," sometimes mentioned in reporting the presence of "insects" which had bitten persons who later suffered relapsing fever. Four days after being bitten by the tick, blood smears made from this mouse proved positive for spirochaetes and these were found continuously in this animal for about a month. Blood taken from the tail of this mouse and mixed with one cc. of sterile salt solution was inoculated into two normal mice with spirochaetes appearing in the blood of these latter animals on the third day after inoculation. A total of eighteen successful transfers into white mice was made in this series. Proof is evident from this test as well as the monkey test that the infection occurs in ticks taken in nature at Big Bear Lake.

Due to the paucity of ticks taken in nature from the Lake Tahoe region and to accidents that have befallen even this small amount of material, we have had little to work with from that locality, except as we now have ample progeny from that source. However, as stated below, two female ticks taken in a relapsing fever cabin at Lake Tahoe proved somewhat doubtfully positive on a monkey, but eggs from one female produced larvae, a small percentage of which actually did prove positive to white mice.

As the result of our tests begun in September, 1934, with ticks taken in nature at Big Bear Lake, using 24 individual ticks fed on a like number of white mice, five proved positive. This indicates what one would expect, namely, that only a small percentage of ticks taken at relapsing fever foci are infective, in this case about 20 per cent. However, this condition is somewhat complicated in that the offspring of a female tick from Lake Tahoe which had been tested repeatedly with negative results, have given positive results in at least one instance,—that is, the larvae of

a negative tick proved positive. Also, conversely the larvae from four lots of eggs of a tick (No. 5) which had been proved positive in four different tests produced offspring, 131 of which were tested individually in all stages on white mice; a total of more than 300 mice were used in this test, all with negative results. The offspring of other experimentally infected female ticks (No. 7^{I}) gave similar negative results on testing; however, in the case of No. 7^{II} the first batch of larvae proved negative while the second batch gave positive results. When "clean" larval ticks are permitted to feed upon white mice previously infected by the bite of a tick, the larvae pick up the infection and about 30 per cent of the individuals transmit the disease in some subsequent developmental stage to healthy mice.

Hereditary transmission of the spirochaetes from the female tick to egg to larva to white mouse has now been effected for both the Big Bear Lake and the Lake Tahoe strains. The percentage of infective larvae in hereditary transmission appears to be quite low, indications being less than two per cent. Not enough tests have been completed to provide us with sufficient data for safe percentage estimates.

Tests are now under way to determine more accurately the percentage of infective offspring in hereditary transmission. Until a considerable number of tests have been completed no attempt is being made to explain why offspring of both non-infective and infective female ticks may or may not be infective and why infection may in some instances result from larval ticks and in others infection does not result until later instars, even skipping instars. To illustrate this phase of our work the following example will suffice. Female tick No. 7^{II} which had been proved positive laid two batches of eggs with an interval of about 16 days. The larvae of the first batch of eggs numbering 82 were tested on white mice in seven lots of ten and one lot of twelve, thus using eight mice. The results were negative as have been the results with the later instars to date, feeding being continued by lots of ten and twelve.

The larvae from the second lot of eggs numbering 74 were fed on white mice in seven lots of ten and one of four, again eight mice being used. In this test lot No. 5 (ten larvae) gave positive results, all others being negative and remaining negative for later feedings in later instars. Lot No. 5 (positive) was now segregated, each larva being placed separately in a pill box in the meantime passing to the first nymphal stage and tested individually on clean mice (ten). The results were negative in spite of the fact that the larval instar was positive. Next the same treatment was given the nine ticks (one was killed) now in the second nymphal instar. This individual treatment was again repeated for the third nymphal instar with one transmission (i.e., one mouse proved positive for spirochaetes), spirochaetes being recovered in the blood of the

mouse on the fifth day after being bitten by a tick. The final instar (adult) had not yet been reached at this writing.

It may now be safely reported that infections may be accomplished by the bite of both mature male and female ticks and in all instars—larval and nymphal. The larval stage is, of course, only infective, if at all, as the result of hereditary infection from an infected female, because feeding is done only once in this stage (as well as all immature stages, for that matter). Spirochaetes are usually recoverable in the blood of white mice in about five days after being bitten by our infective ticks. One mature female has produced four infections at intervals during a period of about four months. Larvae from a presumably non-infective female tick produced infections and conversely the larvae of an infective female tick may not be infective although later instars may be.

TECHNIQUE

Except where otherwise mentioned when mice were experimentally inoculated, a human strain of spirochaete originating at Lake Tahoe was used. Infected ticks taken in nature at Big Bear Lake furnished another strain, so that spirochaetes from both major foci were used in our laboratory tests. Mouse inoculations were done both intraperitoneally and subcutaneously with blood (six drops) taken from the tail of an infected mouse, the blood being mixed with one cc. saline. Spirochaetes usually appeared abundantly in the blood of the inoculated mouse in about three days. Ticks readily became infected by attaching and sucking the blood of these experimentally infected white mice. The time elapsing before these ticks transmitted the infection depended, of course, on the interval from the molt to feeding when the ticks were ready to feed again (with molting intervening); this elapsed time varied in different stages from 10 to 32 days. These ticks evidently remain infectious for the rest of their lives and are able of course to infect a number of experimental animals. Over a period of about 12 months one tick has infected a monkey and three white mice. Transmissions by means of interrupted feedings have so far been unsuccessful. Ticks are fed on mice immobilized in a tubular piece of hardware cloth plugged with cotton. For our purposes staining of blood smears is done with oxylated gentian violet stain. Ticks are reared in a temperature control cabinet at a constant temperature of 75° F. and humidity well over 90 per cent, each individual tick being kept in a small pasteboard pill box.

THE TICK VECTOR—LIFE HISTORY AND HABITS

The tick, shown to be a vector of relapsing fever infection in the above outlined tests, was early recognized as a new species and in July, 1935, was described as *Ornithodoros hermsi* by C. M. Wheeler (1935).

Our knowledge concerning the distribution of this species is as yet too meagre to generalize safely, but what material we have collected in the field indicates a distribution in the Sierra Nevada and San Bernardino mountain ranges at elevations of from about 5000 to about 8000 feet. It appears to be typically a parasite of rodents, but like other species of the same genus, feeds freely on a variety of experimental animals as well as human beings. We have taken numerous specimens in all stages of development except larvae in the nests of chipmunks in cottages used as summer homes in the mountains.

This species of tick is rather small compared with others of the same genus. The female measures from 5 to 6 mm. in length by 3 to 4 mm. in width, while the male is only slightly smaller and resembles the female. It "differs from *Ornithodoros talaje,* a close relative, in (a) the absence of large discs on the dorsum, (b) the characteristic sculpturing of the integument, (c) microscopical differences in the structure of the integument, (d) arrangement of the dentition of the hypostome, (e) the absence of lateral flap-like borders at the margins of the capitulum, (f) the shape of the cheliceral teeth, (g) the shape of the anal grooves, and (h) the tarsi bearing diagnostic protuberances. This new species differs from *Ornithodoros venezuelensis* in (a) the sculpturing of the dorsum, (b) the protuberances of the tarsi, (c) shape and position of anal grooves, and (d) the dentition of the hypostome. This new tick differs from *Ornithodoros turicata* in (a) the absence of clubbed hairs between the mammillae, (b) the arrangement and number of teeth on the hypostome, (c) the decidedly smaller hypostome, (d) the arrangement and number of protuberances on tarsi I and IV in particular, and (e) the smaller size of the adults." (Wheeler, loc. cit.)

From our observations in the laboratory where our material is kept at a constant temperature and humidity, we find that the number of eggs deposited per female ranges well over 200, deposited at intervals in batches of 12 to 140 from May to October. A specific example follows: Female tick, No. 5, taken as a last stage nymph August 17, 1934, deposited a total of 232 eggs in four batches, 98 (April 8), 73 (May 19), 49 (May 26), and 12 (June 12) with but one feeding (i.e., after first batch was laid) between egg-layings, and died October 21, 1935.

The incubation period at the temperature mentioned above, namely, 75° F. ranges from 15 to 21 days. The percentage of larvae hatching seems to grow less in the later egg-layings, as high as 95 per cent for the first batches down to less than 50 per cent in the last. The first molt is usually accomplished within the egg; however, the larva remains hexapod until after the second molt. After about three days the larva is ready to feed, remaining attached to the host for only about 12 to 15 minutes as is the case in later stages although this attachment in the

latter may be for from one-half to one hour in many cases. Molting takes place in about 15 days after feeding. With this molt the fourth pair of legs appears, and this stage is termed the first nymphal instar. The first nymphal stage may feed within a few hours after molting and again a period of 11 to 15 days elapses before the third molt and the appearance of the second nymphal instar. Then follows the third feeding and again an elapsed period, in this case about 10 to 32 days before the fourth molt and the appearance of the third nymphal instar or even the adult may appear with this molt. Usually a fifth feeding and a fifth molt are necessary before sexual maturity is reached. Egg-laying may begin in about 30 days after the last molt, fecundation taking place in a few days after reaching maturity. The cycle from egg to egg under our laboratory conditions requires about four months—e.g., from April 29 when eggs were laid to August 24, when eggs were laid by a female from the April 29 hatch of eggs.

The life cycle may be greatly prolonged because of the ability of these ticks to withstand starvation; thus larvae may live as long as 75 days without food; unfed first molt nymphs are still living at this writing after about four and one-half months, having reached this stage on July 15. With only three feedings in the interim one adult tick taken in nature August 17, 1934, a period of about 14 months, is still living. Ticks of this genus are notoriously long lived. We have in our laboratory individuals of *Ornithodoros coriaceus,* taken over four and one-half years ago (June, 1931) as adults, still living with feedings about twice a year. Without food an adult female *Ornithodoros megnini* was kept alive for over two years and seven months, not counting the unknown time prior to coming into our hands.

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THE WESTERN DOG TICK, *DERMACENTOR OCCIDENTALIS* NEUM., A VECTOR OF BOVINE ANAPLASMOSIS IN CALIFORNIA

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According to Boynton (1932) anaplasmosis of cattle was first definitely diagnosed in California during December, 1925, although lesions and symptoms characteristic of anaplasmosis had been observed by veterinarians for a number of years previous to that. The etiological agent, *Anaplasma marginale* Theiler, 1910, was not incriminated until the December, 1925, outbreak (Boynton).

Ticks were incriminated as vectors of this disease as long ago as 1910 by Theiler working in South Africa and horse flies (Tabanidae), on meager evidence, were incriminated, in one instance only, in 1930 by Sanborn, Stiles, Moe and Orr (1930) working in Oklahoma. Extensive work was done by Rees (1934) in Louisiana, who added four additional species making a total of fifteen.

The positive cases reported by Rees were non-hereditary tick transmissions except one which resulted from hereditary transmission by *Boöphilus annulatus* Say. In this paper we are able to report three hereditary transmissions and add two new tick vectors, namely, *Dermacentor occidentalis* Neum. and *Dermacentor albipictus* Packard.

EXPERIMENTAL CASES

Case I (hereditary transmission).

On May 28, 1935, 17 adults of the western dog tick, *Dermacentor occidentalis* Neum., which had been collected from shrubbery on Mt. Diablo (elevation 2500 feet), were placed on cow 130, with a clinical case of anaplasmosis having been induced by adult spotted fever ticks, *Dermacentor andersoni* Stiles. The ticks were removed June 1, remaining on the cow about four days, and kept in the laboratory under controlled conditions. Eggs were laid June 18–21, and larvae hatched July 29 to August 4. August 19 numerous larvae (2000–3000) from this brood (*Dermacentor occidentalis*) were placed in a small bag and attached to the scrotal sac of bull 194 and removed August 23, a period of four days' exposure.

Marginal bodies first appeared in the blood of bull 194 September 25, thirty-seven days after the application of the larval ticks. Two days later the bodies were numerous and the blood count dropped in characteristic manner.

Case II (hereditary transmission).

The larvae responsible for case I (bull 194) were kept in pill boxes, allowed to molt and were then applied to the scrotal sac of bull 198 October 31, 1935. These nymphs were allowed to feed to repletion on this animal and were removed November 10, 1935, an exposure of ten days. Suggestive marginal bodies appeared in the blood of bull 198 November 29, 1935, and definite bodies were found December 2, thirty-two days after the ticks were applied. This case proves that infection is carried by nymphs as well as larvae.

Case III (hereditary transmission).

Fully engorged mature western dog ticks, *D. occidentalis* Neum., were removed from a Hereford cow on a ranch near Walnut Creek. This animal was suffering from a naturally infected case of clinical anaplasmosis as shown by blood smears and later postmortem examination by Dr. Boynton. These ticks were brought into the laboratory January 5, 1935, and laid eggs from February 1 to 15. These eggs hatched between February 28 and March 6. Larvae numbering 2000 to 3000 from several of these egg masses were placed on a teat of cow 1242 March 7, and allowed to feed until their removal, March 21.

Frequent blood examinations failed to show definite anaplasmid bodies until over four months had elapsed. A blood examination, July 8, showed a few marginal bodies; these continued to increase in number until the death of the animal ten days later. A postmortem examination by Dr. Boynton revealed the typical symptoms of bovine anaplasmosis. From the time the ticks had been applied to the time marginal bodies appeared was 123 days.

Case IV (non-hereditary, *Dermacentor albipictus,* vector).

February 19, 1935, replete winter ticks, *D. albipictus* Packard, were collected in the shipping corrals at Davis, California. These ticks laid eggs from March 1 to 14, the larvae hatching April 2 to 16, 1935. The larvae were fed on bull 194 (Case I) while it was suffering from a clinical case of anaplasmosis. After molting the resulting nymphs were placed on the scrotal sac of bull 196 October 18 and removed November 10, 1935.

Definite anaplasma bodies were seen in the blood smears November 15 and were numerous November 17 but the animal did not develop clinical symptoms. Time elapsing between application of the nymphal ticks and appearance of marginal bodies was 30 days.

Case V (non-hereditary, *Dermacentor andersoni,* vector).

On April 18, 1935, adults of the Rocky Mountain spotted fever tick, which had become engorged on cow 2652, experimentally infected with

anaplasmosis, were placed on cow 130 and allowed to remain until April 23, 1935.

Twenty-nine days later numerous anaplasma were found in the blood smears and the animal developed an acute case of anaplasmosis from which it slowly recovered.

LIFE HISTORY AND DISTRIBUTION OF THE TICK VECTOR

Host Relationships: The type of this species (*Dermacentor occidentalis* Neum.) was collected from deer, but Hooker, Bishopp and Wood (1912) list the following host animals according to the frequency with which the ticks are found: cattle, horses, man, deer, mule, dog, ass, rabbit, and sheep.

The ticks are found during all seasons of the year on these hosts, but are most numerous during the rainy season. Adults are most frequently taken, but we have taken all stages from cattle. As pointed out by Rees (1930) the larvae and nymphs because of their small size are seldom seen on large animals even though the ticks may be present in large numbers.

Geographical Distribution: The western dog tick or Pacific tick is the commonest Ixodine tick in California and may be found in practically all of the hilly areas of the state. Records show that it is common from central Oregon to Lower California. The type locality is Occidental, Stanislaus County, California.

Life History: The life history of this tick has been admirably worked out by Hooker, Bishopp, and Wood (1913) and work done in this laboratory checks rather closely with their observations. The average preoviposition period for ticks in this laboratory was 21 days with a minimum of 18 and a maximum of 41 days observed. Twenty-five days was the minimum incubation period, the average was 32 days. Larvae which did not feed were all dead 93 days after hatching and most of them were dead in less than two months. Hooker, Bishopp, and Wood record a longevity period of 124 days.

The average engorgement period of larvae is about 4 days although 14 days after attachment some had not fed to repletion. Molting occurred from 7 to 11 days after dropping from the host and nymphs fed readily from this time on. A maximum longevity period of 114 days is given with an average of about 60 days.

Nymphs fed in six days with a maximum of 11 days. Molting occurred from 15 to 25 days after dropping from host with little difference noted as to the emergence time of the sexes.

Adults fed in about 7 days but many were replete after 3 days, especially during warmer weather. No correlation was noted between time of feeding and number of eggs laid except that females which had not

fed to repletion were unable to lay as many eggs and in one case the eggs laid were sterile.

TECHNIQUE

The animals used in these experiments were Holsteins from the University experimental herd; no cases have been found in this herd except those experimentally induced. All animals tested have been positive, suggesting that the animals have not had subclinical cases of anaplasmosis.

During the experiments the animals were kept in the isolation barns of the Veterinary Science Division of the University of California in individual stalls where the possibility of accidental transmission was reduced to a minimum. No nose tongs or goads were used on these animals in order to avoid accidental infection in this way; all bleeding needles were carefully sterilized before being used a second time.

All ticks, when not on the experimental animals, were kept in pill boxes in a constant temperature chamber over moist sand or in a desiccator jar containing a saturated solution of $Na_2SO_4 \cdot 10\ H_2O$ which gave a relative humidity of 93 per cent $\pm$ 1/2 per cent with a temperature of 23° C. $\pm$ 2°.

On the animal, the ticks were confined in one of three ways, depending upon the age of the ticks and the sex of the animal. Nymphal and adult ticks were placed in a small round metal pill box from which both the top and bottom had been removed. When these openings were covered with bobbinet, the container fitted snugly into an outer guard which was made of a quarter pound ether can from which the top had been removed, the sides of which were cut into strips about an inch wide, to within three-fourths of an inch of the bottom and then bent at a 90° angle to form what resembled the spokes of a wheel. By cutting a hole in the bottom of this can nearly as large as the diameter, it is possible to observe the ticks without disturbing the container. The rays or spokes form very satisfactory points for attachment by means of adhesive tape and may be bent to conform to the contour of the animal's body. This was usually placed on the flank and held better if the hair was closely clipped or shaved.

Larval ticks when put on the teat of a cow or all stages to be put on a male animal were confined in a small sack, the opening of which was lined by a half inch strip of lamb's wool. This material prevents the escape of the tiny larvae and provides more comfort for the experimental animal. The bag was secured by means of a drawstring and adhesive tape. Blood smears for the diagnosis of anaplasmosis were prepared on coverslips rather than on slides. These were fixed in osmic acid vapor or

formalin and stained with methylene blue or Toisson's fluid. Wright's stain furnished a rapid and convenient means of diagnosis.

DISCUSSION

There are three species of ticks in California which are commonly found on cattle and may be confused with the western dog tick, *Dermacentor occidentalis* Neum.: namely the Rocky Mountain spotted fever tick, *D. andersoni*; the common dog tick, *D. variabilis*; and the winter tick, *D. albipictus*. The first is most easily confused but differs in having large porose areas, hind coxae twice as broad as long at the base, a narrow dorsal prolongation of the stigmal plate, and over a hundred goblet cells in the stigmal plate. The western dog tick is separated from *D. variabilis* in that it (the former) lacks a broad dorsal prolongation of the stigmal plate and in having less than a hundred goblet cells in the stigmal plate. The winter tick may be recognized by its elongate form, especially the long shield, the larger number of goblet cells, and by its larger size.

Under laboratory conditions the immature stages of the western dog tick are less able to withstand long periods without feeding than the others. This suggests that pasture rotation may be useful in the control of this tick and the disease it carries. Successful utilization of this plan would involve the exclusion of other host animals such as rodents, canines, horses, and deer. Boynton (1933) has shown that the last named host may be a reservoir of anaplasmosis; both the southern blacktailed deer, *Odocoileus columbianis scopiatus* Merriam, and the Rocky Mountain mule deer, *Odocoileus hemoinus hemoinus* (Rafinesque), having been incriminated. Daubney (1934) mentions several cases where outbreaks of anaplasmosis have been caused by allowing reservoir animals to enter "free" areas.

The presence of anaplasmosis in sheep and goats without clinical manifestations should be noted, and they may be considered as possible reservoirs.

Experiments here reported indicate that *D. occidentalis* is an important vector of anaplasmosis in California, probably the most important of all. It is a widely distributed and abundant tick, having a wide host range and is frequently found in all stages except larval (which may be easily missed on inspection) on cattle and deer, the latter a proven carrier of anaplasmosis which may be responsible for some outbreaks.

Five cases of tick transmission are here reported, two non-hereditary and three in which the infection passed through the eggs of the western dog tick, the offspring being infective in both the larval and nymphal stages.

ACKNOWLEDGMENT

The authors wish to gratefully acknowledge the cooperation of Dr. William Hutchins Boynton and Miss Gladys M. Woods, both of the Division of Veterinary Science, University of California. A joint paper with Dr. Boynton and Miss Woods dealing in greater detail with certain aspects of this problem has been prepared for publication elsewhere. (Boynton, et al., 1936.)

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RESEARCH NOTES

UNISEXUAL INFECTION WITH *SCHISTOSOMA MANSONI*

The feces of a patient containing numerous eggs of *Schistosoma mansoni* were passed through a screen, diluted in tap water, and the sediment washed several times. The feces were then left at room temperature for 24 hours to allow the eggs to hatch. With the aid of a binocular microscope and a capillary pipette nine miracidia were isolated in clean drops of water in watch glasses. To each watch glass was added a mollusk intermediate host of *S. mansoni, Australorbis glabratus* (syn. *Planorbis quadeloupensis*Q, which was kept in constant contact with the water. The snails used were considered to be negative for *Schistosoma* infection since they were collected from a non-endemic zone of Schistosomiasis in Puerto Rico, and were maintained in the laboratory for some time in order to check their negativeness.

After half an hour of contact with the drop of water containing a single miracidium, the snails were isolated in different jars and fed daily with fresh lettuce. After 36 days of observation, on October 21, 1935, from one snail were seen to escape active cercariae. With the cercariae obtained from this snail a rabbit was infected on the 37th day by placing water containing cercariae on the shaved skin of the abdomen. On the following day the rabbit was again infected in the same manner with cercariae from the same snail.

About two months after the infection, on December 17, 1935, the rabbit was killed. The liver was dissected out, after the portal and the superhepatic veins were ligated in order to collect all the blood contained in them. The liver was washed and teased apart in physiological saline solution and 63 worms were recovered, all males. Three couples, all males, were found in the copula position. The three males observed in the gynaecophoral canals of other males were of smaller size. The worms remained in this position in saline solution. A separation was effected by adding a dilute solution of Fouadin to the saline solution. Figure 1*A* shows a couple of worms with their anterior extremities on opposite ends during

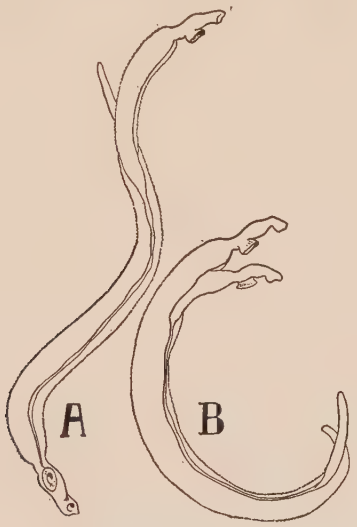


FIG. 1. Diagrams showing male worms in copula in a case of unisexual infection with *S. mansoni.*

their separation observed under the microscope. Two other couples were seen with their anterior extremities at the same end, as shown in figure 1*B*.

This observation on the development of only males from an infection by a single miracidium of the snail intermediate host confirms the hypothesis of Cort (1921, Science, 53: 226–228) that the sexual differentiation of the family *Schistosomatidae* begins in the fertilized egg. The first definite evidence for this was given by Lindner (1914, Archiv. für Zellforschung, vol. 12) who working on *Schistosoma haematobium* described a heterozygous condition in the male, one half of the spermatids having eight chromosomes, the other half having six. An undoubted demonstration of this sexual differentiation was shown in investigations on *Schistosoma japonicum* reported by Tanabe (1919, in Japanese, cited by Cort, 1921), Faust (1927, Jour. Parasit., 14: 62–63), and Severinghaus (1928, Quart. Jour. Micro. Sci., 71: 653–702).

The unisexual infection with *Schistosoma mansoni* reported in this note is in accordance with the researches previously made on other species of the family *Schistosomatidae*. Some consideration will be given to the new observation of male worms in copula in an attempt to give a possible explanation of it and to determine its importance in the pathology of the infested host.

In the case of unisexual infestations with worms of the family Schistosomatidae, the absence of the opposite sex has certainly some importance in the development of the parasitic worms as well as in determining their sexual activity. A classical example of the influence of environment on sexual development was reported by Gould (1917, Jour. Exp. Zool., 23: 225–250). He found that a young individual of *Crepidula plana* becomes a female if solitary, but should it settle down near an adult female it becomes a male and remains so permanently. This great influence of the environment certainly does not exist in the Schistosomatidae, since sex is determined in the fertilized egg. But Yokogawa (cited by Cort, 1921) has already reportd that in unisexual infections of *Schistosoma japonicum* the worms failed to develop to maturity. Later Severinghaus (cited above) showed that the females allowed to develop in the mammalian host in the absence of males, fail to develop both as regards somatic and germ structures. Severinghaus showed also that when males only are present they can mature and attain almost the same size as the males paired with females, but they mature slowly and also they can become smaller again with age.

The finding of couples of males paired seems to justify the idea that partial specialization of male worms of *Schistosoma mansoni* may occur when male worms only are present in the vertebrate host. Some of them attain a complete sexual maturity, while some other remain smaller or become smaller again with age and can be clasped in the gynaecophoral canal of the larger ones.

The human infestation with male worms only of *Schistosoma mansoni* has been recently identified by Rameses Girges (1934, Schistosomiasis, John Bale and Sons, London) with the Egyptian splenomegaly. This syndrome begins with a hepatomegaly which is followed by an atrophic cirrhosis of the liver and a splenomegaly complicated sometimes by ascites. According to Girges' view the male worms, finding no females to accompany them to their definitive position in the host, the mesenteric veins, remain in the liver causing important damage to that organ by their metabolic excretions and other toxins. Being confined in the smaller branches of the portal vein they are in close proximity to the liver cells and produce a mechanical action against these cells. The possibility of the presence of couples of male worms in the infestations with male worms alone can be considered as a greater source of damage to the liver than single worms. Two male worms coupled constitute indeed a unity of greater size than a single worm. They exercise a greater mechanical action on the liver cells and can more readily cause an obstruction of the smaller branches of the portal system.—ARNALDO GIOVANNOLA (*Italy*), *Rockefeller Foundation Fellow. From the University Hospital and the Parasitological Department of the School of Tropical Medicine of Puerto Rico.*

A NEW METHOD FOR EMBRYONATING NEMATODE EGGS IN FECAL DISCHARGES

In the course of some parasitological studies, the author was faced with the problem of infecting a large number of chickens with the intestinal nematode, *Capillaria columbae*. The life cycle of this parasite is direct, involving the embryonation of worm eggs outside the body of the host for one week. There was available as a source of material only one live bird which apparently had a light infection as determined by the small number of worm eggs found in the fecal examinations.

At first the attempt was made to embryonate the parasite eggs by incubating the feces in a two per cent potassium dichromate solution to prevent putrefaction. This method was unsatisfactory because many of the embryos died before complete development took place. Furthermore, the amount of material was greatly increased. This necessitated a great deal of incubator space since the feces dichromate mixture had to be placed in shallow layers to permit sufficient oxygenation.

The method finally adopted not only prevented putrefaction and allowed for sufficient oxygenation, but also decreased the bulk of the manure itself. A colony of house flies (*Musca domestica*) was maintained according to the method worked out by Miss Evelyn George (Department of Entomology, Cornell University) (22nd Annual Report, N. Y. S. Conservation Dept., p. 307, 1932) for the lesser stable fly *Muscina stabulans*. Following her method, the flies were allowed to oviposit on pieces of hard-boiled eggs and the fly eggs were hatched at 30 degrees C. in a small amount of wet mash composed of ground alfalfa 6 parts, dry skim milk 1 part, and ground soy bean meal 1 part. After 24 hour incubation the fly larvae were removed from the mash and placed in a pan of feces containing the nematode eggs. This was kept at a temperature of 24 to 27 degrees C. After four to six days incubation, depending on the amount of feces present and the number of fly larvae introduced, the putrescible matter in the manure was entirely consumed by the developing maggots. This could be ascertained by the complete absence of any foul odors. An excess of fly larvae is desirable since less time is needed for the complete utilization of the putrescible matter. At this time most of the fly larvae were removed, the residue moistened and incubated at 30 degrees C. for 7 days. A few larvae were always allowed to remain since they were of great value in helping aerate the mass by their continual movements through it.

Microscopic examination of the parasite eggs embryonated in this manner disclosed no visible injury either to the egg shell or to the coiled embryo itself. By the repeated feeding of the manure treated in this way it was possible to produce a heavy infection with the nematode in a large number of birds.

It is quite conceivable that this method can be easily modified to permit one to embryonate nematode eggs from other species of animals, especially where the source of the material is limited.—P. P. Levine, *Department of Pathology and Bacteriology, New York State Veterinary College, Cornell University, Ithaca, New York.*

BIRD MALARIA TRANSMITTED BY THE INTRAVENOUS INJECTION OF SPOROZOITES

Attempts to transmit avian *Plasmodium* by the intravenous inoculation of sporozoites have all been negative. Majid and Sinton (Ind. Jour. Med. Res., 21: 455–466, 1933) injected intravenously into one bird at four different times sporozoites derived from 30 lobes of salivary glands from infected mosquitoes. No infection was produced although the sporozoites at the time they were injected were motile and appeared to be normal. The sporozoites from six lobes of infected salivary glands were injected intravenously into a second sparrow on two occasions; those injected the first time were motile while those used for the in-

jection on the second occasion were not motile. The negative results in both sparrows were not checked by subinoculation.

More recently, Raffaele (Riv. di Malar., 13: 395–403, 1934) inoculated sporozoites directly into the blood of nine canaries, in the leg vein of three and in the heart of six. He stated that the first bird was injected with the sporozoites from 32 infected *Culex* and was negative during a period of 18 days. When the bird was then inoculated with sporozoites subcutaneously, it showed an infection after a prepatent period of five days. The periods during which the other birds were examined and found negative were not stated, and the negative observations were not checked by subinoculation. Raffaele came to the conclusion that the sporozoites injected directly into the blood stream are rapidly destroyed and therefore avian *Plasmodium* can not be transmitted by the intravenous injection of sporozoites.

On the other hand, it is well known that human malaria can be transmitted by the intravenous injection of sporozoites (James, Nichol and Shute, Trans. Soc. Trop. Med. and Hyg., 21: 233–236, 1927; Bruce Mayne, Public Health Reports, 48: 909–916, 1933; Raffaele, Riv. di Malar., 13: 706–707; De Sanctis Monaldi, Riv. di Malar. 14: 344–352. 1935).

It appeared, therefore, worth while to repeat the intravenous inoculation of sporozoites of avian *Plasmodium* in order to test the results of Majid and Sinton and of Raffaele.

The present note reports one unsuccessful and two successful attempts to infect birds with *P. praecox* (*P. capistrani* Russell, 1932) by the intravenous injection of sporozoites. The salivary glands of 12 infected *Culex pipiens* were dissected out, in a solution of 1% of sodium citrate in 0.7% sodium chloride to which one drop of sterile bovine serum per cc. was added, on the 18th day after the infective blood meal. The sporozoites were kept in this solution at room temperature for about three hours and then one-half of the amount was injected into three clean canaries. Each of them received 150 mgms. of solution containing the sporozoites from about 2 infected mosquitoes. In order to make certain that the injection was made directly into the blood stream and that no sporozoites were lost in the subcutaneous tissue two syringes were used. The first was filled with the above solution containing no sporozoites and 50 mgms. of this was injected. This syringe was then removed (with the help of an assistant) while the needle remained inserted into the vein and the second syringe containing the sporozoites was rapidly inserted into the needle.

In the first canary an infection was observed after a prepatent period of 10 days. In the second canary a few specimens were observed after a prepatent period of about the same length. Four weeks after the original inoculation the blood of the second canary was inoculated intravenously into a clean bird; in this bird parasites were observed within two weeks. The third bird showed no parasites.

On the basis of results reported above it is concluded that bird malaria as well as human malaria can be transmitted by intravenous inoculation of sporozoites.—Fruma Wolfson, *Department of Protozoology, School of Hygiene and Public Health, Johns Hopkins University.*

INVERSION IN THE PERIODICITY OF EMISSION OF CERCARIAE FROM THEIR SNAIL HOSTS BY REVERSAL OF LIGHT AND DARKNESS

Snails parasitized by three species of larval trematodes kept in a dark room during the day and in a box with a strong electric lamp during the night showed an inversion in the periodicity of emission of cercariae. The snails were isolated in single jars during the period of the experiment, the water in the jars being changed at six-hour intervals and the cercariae present counted. A dilution count was used according to the following technic: The snails were maintained in

bottles containing 98 cc. of water. When the cercariae were to be counted the snail was removed to a new bottle and two cc. of a 5% iodine solution in 70% alcohol was added in order to kill and stain the cercariae and to raise the quantity of water to 100 cc. The bottle was then closed with a cork, shaken and one cc. was taken with a large pipette and poured in a watch glass. The number of cercariae counted was multiplied by 100 in order to obtain the total number of cercariae in the bottle. To obtain a more exact value the count was repeated two to three times. In some cases in which the number of cercariae emerged was not enough to obtain a uniform distribution in the water, a direct count was made.

A snail, *Heliosoma trivolvis,* infested with an unidentified forked-tailed cercaria closely related to *Cercaria brevifurca* McCoy 1929 was maintained under normal conditions for 7 days. The cercariae counted during the first 4 days showed a regular periodicity in their emission with a peak from 5:30 to 11:30 A. M. The same snail was kept in an aquarium for the remaining three days and then was put under conditions where the periods of light and darkness were reversed. An inversion of periodicity was obtained with the peak from 5:30 P. M. to 11:30 P. M. Figure 1 shows the number of cercariae counted at six-hour intervals during the two phases of the experiment.

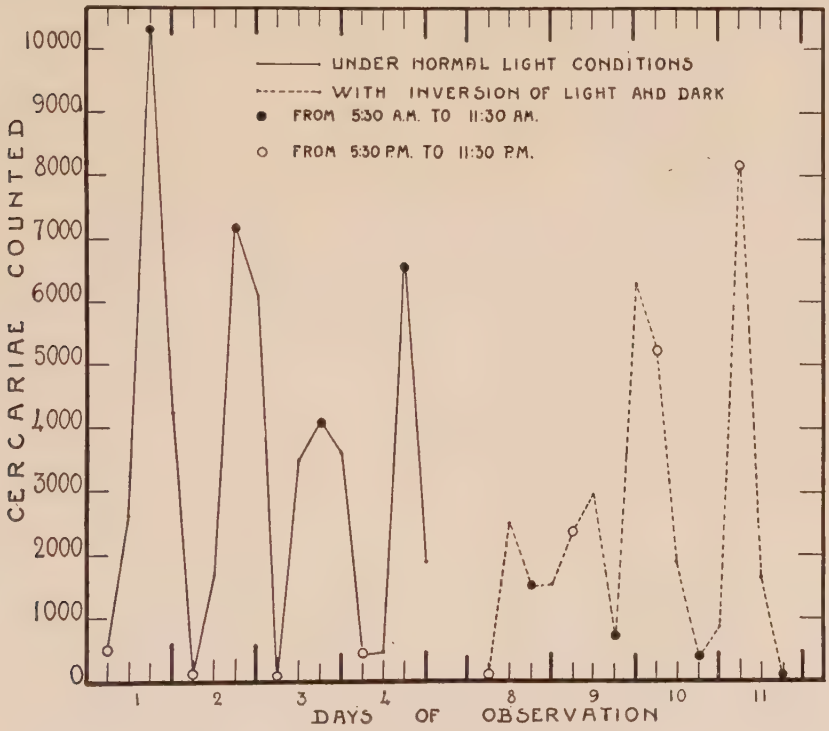


Fig. 1. Numbers of *Cercaria* sp. (closely related to *Cercaria brevifurca* McCoy 1929) that emerged from a specimen of *H. trivolvis,* maintained first under normal conditions and then under conditions where the periods of light and darkness were reversed. The count of cercariae was made at six-hour intervals.

Three specimens of *Stagnicola emarginata angulata* parasitized by larval stages of *Diplostomum flexicaudum* were maintained with reversal of light and darkness while four other snails of the same species parasitized with the same

trematode were kept in normal conditions as controls. The snails maintained under normal conditions showed a regular periodicity in the escape of the cercariae, the peak of which occurred from 11:30 A. M. to 5:30 P. M. The snails maintained under conditions where the periods of light and darkness were reversed showed the same type of periodicity for the first 24 hours of observation, then the periodicity of the escape changed gradually and an inversion of periodicity with its peak from 11:30 P. M. to 5:30 A. M. was evident in all three snails. Figure 2 shows the average of the numbers of cercariae which escaped at six-hour intervals from the two groups of snails.

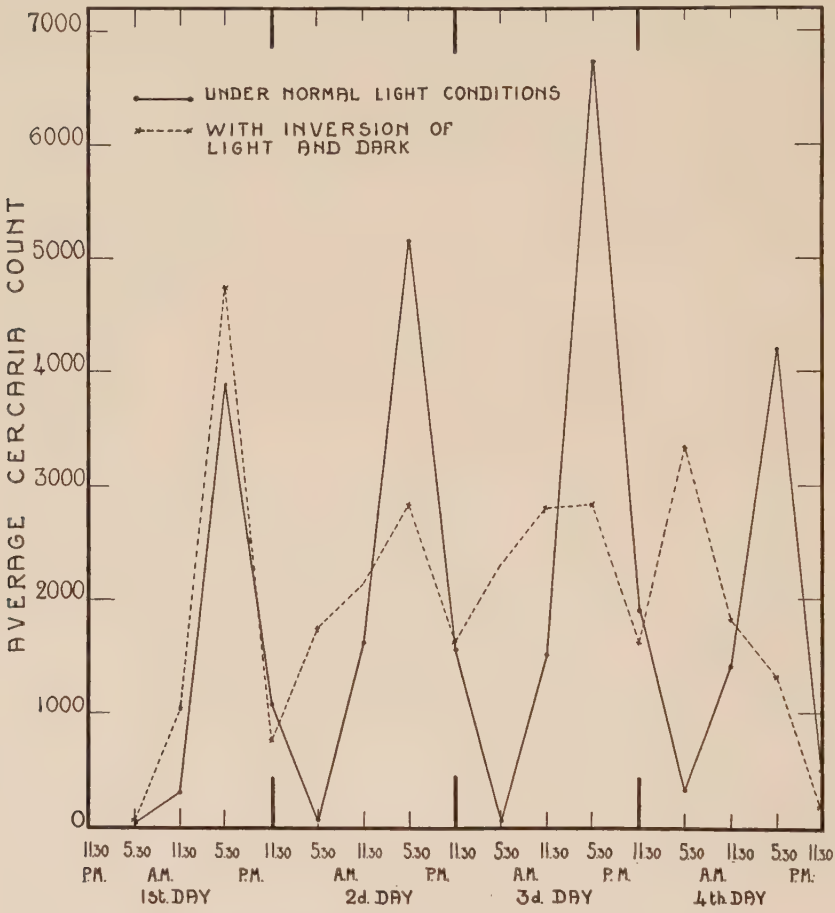


Fig. 2. Averages of the numbers of cercariae of *Diplostomum flexicaudum* that emerged from three specimens of *Stagnicola emarginata angulata* maintained with reversal of light and darkness and from four other specimens kept in normal conditions.

An evident inversion of periodicity was also observed in a cercaria of a species of the subfamily Reniferinae from *Physella gyrina*. Figure 3 shows the numbers of cercariae obtained from two of these snails maintained in normal conditions counted at six-hour intervals as compared with those that escaped from one snail for which the periods of light and darkness were reversed. Here,

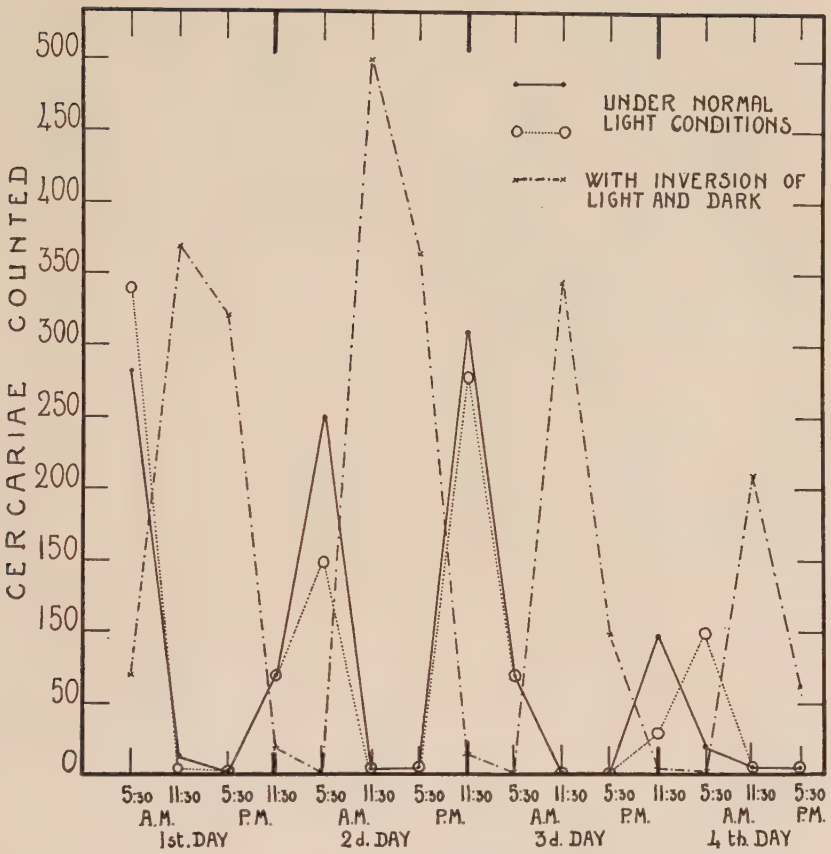


Fig. 3. Numbers of cercariae of a species of the subfamily Reniferinae which emerged from three specimens of *Physella gyrina*. Two snails were maintained in normal conditions, one snail was kept with the periods of light and darkness reversed.

also, there was a reversal of periodicity.—Arnaldo Giovannola (*Rome, Italy*), *Fellow of the Rockefeller Foundation. From the Department of Helminthology of the Johns Hopkins School of Hygiene and Public Health, and the University of Michigan Biological Station.*

A NOTE ON THE LIFE CYCLE OF *MOSESIA CHORDEILESIA* N. SP. (LECITHODENDRIIDAE)

In the examination of numerous may-fly nymphs, collected in Boat House Cove at the University of Michigan Biological Station, it was found that about 50 per cent were infected with a species of Xiphidiocercaria. These metacercariae (Fig. 2) are free in the body. The oral sucker is larger than the acetabulum, pharynx near the former, and remainder of digestive system undeveloped. Remains of two stylet glands can be seen in the second quarter of the body. The excretory bladder is V-shaped, with main excretory ducts entering at the anterior tips of the arms. In the younger metacercariae a small stylet (Fig. 3) is present. The characteristics of these metacercariae at once suggested that they were larval forms of some member of the Lecithodendriidae.

Examination of the snails in the locality yielded a species of cercaria (Fig. 1), from *Goniobasis livescens,* that resembled the metacercaria. There are two stylet glands and the stylet seems to be identical to that found in the metacercaria. It has been impossible, however, to experimentally infect mayfly nymphs, either directly or indirectly.

Six naturally infected mayfly nymphs were fed to a canary. Five days later 15 rather well developed trematodes were recovered from the intestine. To obtain younger developmental stages a second canary was fed twice, with a two-day interval. Five hours after the last feeding the bird was examined. Immature trematodes of two ages were recovered. From the first feeding there were 54 trematodes, from the second 12.

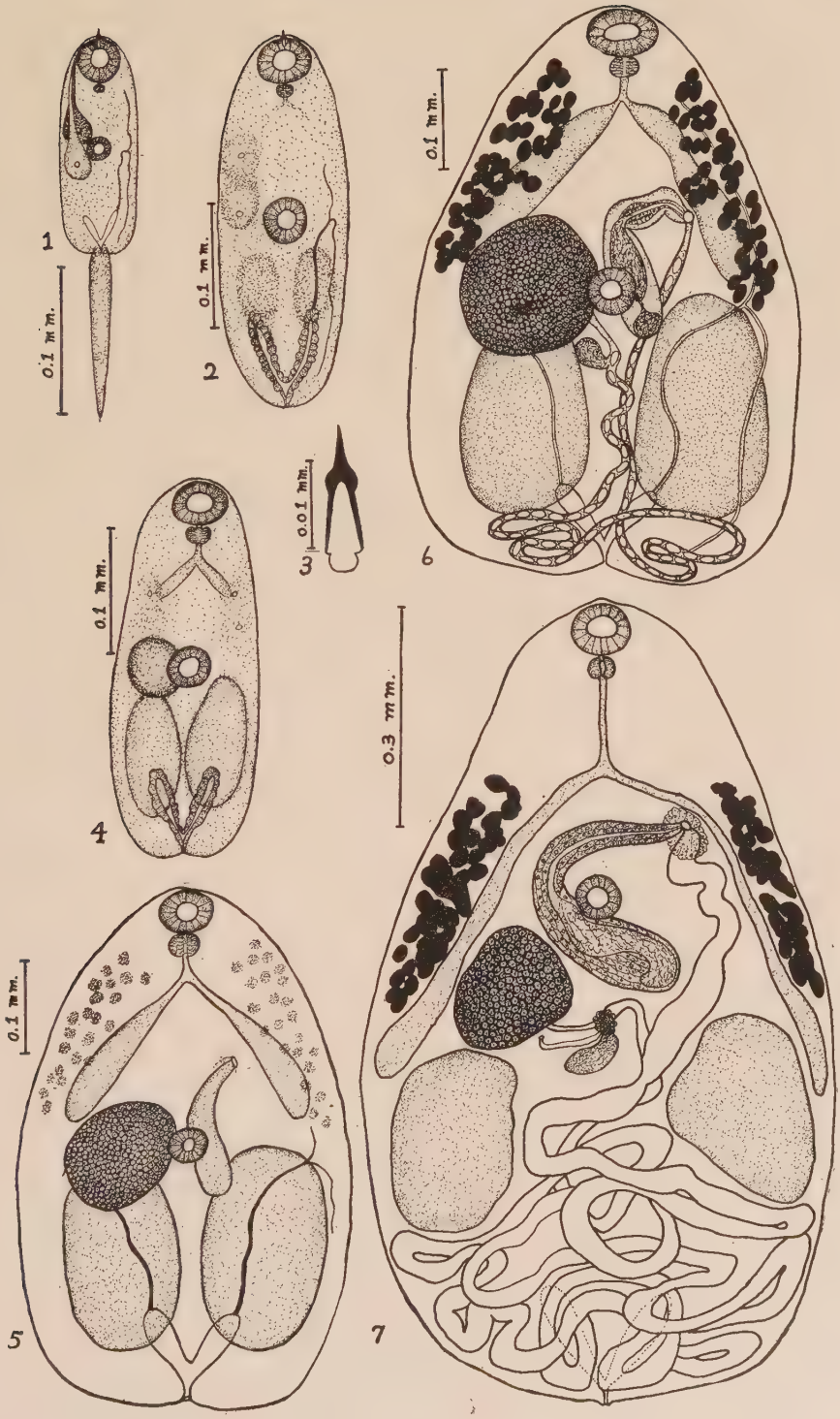
The youngest of these trematodes (Fig. 4) are quite similar in size and structure to the metacercariae. The digestive system is more complete and the reproductive organs are more pronounced. In the two-day old trematodes (Fig. 5) the ovary and testes have increased in size, the cirrus, distal end of the uterus and the vitellaria are plainly visible. The oldest experimental trematodes (Fig. 6), 5 days old, measure about 0.61 × 0.43 mm. when moderately flattened for study of the internal organs. Without flattening they appear much smaller, are heart shaped with a thick, notched posterior end. As in the other stages the body is moderately spined except in the posterior notch. The sucker ratio remains the same. Digestive system fully developed. Genital pore anterior to acetabulum and on left side near intestinal cecum. Cirrus well formed and contains numerous prostate glands and a divided, bulbar seminal vesicle. Testes large and in posterior quadrants of the body. Ovary lies to right of acetabulum. Seminal receptacle present. Uterus passes between testes into posterior end and has immature eggs present. Vitellaria follicular and found in region of intestinal ceca.

These trematodes were found to be the same species as those found in the intestine of the local night-hawks, *Chordeiles minor minor.* Smaller numbers were found in young purple martins. These adult trematodes (Fig. 7) are considered to be a new species of the genus *Mosesia* Travassos, 1929. The suggested name is *Mosesia chordeilesia. Mosesia mosesi* Travassos, 1921, the type species of the genus, is the only other described member of the genus.

Mosesia chordeilesia, n. sp.

Specific diagnosis:—Characters of genus: Adult averages 1.09 × 0.64 mm., covered with small spines except at posterior end. Oral sucker larger than acetabulum. Prepharynx short and esophagus relatively long. Pharynx at posterior border of oral sucker. Intestinal ceca extend posteriorly and laterally to region of testes. Cirrus well developed with many prostate glands. Genital pore anterior to acetabulum and to left, near intestinal cecum. Testes same size, on opposite sides in third quarter of body. Ovary rounded or somewhat lobed, lies posterior and to right of acetabulum. Vitellaria follicular, lying between intestinal ceca and body wall. Coils of uterus pass between testes and form a dense mass in posterior end. Eggs numerous, measure 0.029 × 0.016 mm., and are packed in uterus with 3–6 eggs in a single cross section. Excretory bladder V-shaped, with main excretory tubes attached at tips of bladder arms. Near center of body these ducts branch into anterior and posterior tubules.

Fig. 1. Xiphidiocercaria from *Goniobasis livescens.*
Fig. 2. Metacercaria from naturally infected may-fly nymphs.
Fig. 3. Stylet from cercaria and metacercaria.
Fig. 4. Immature *Mosesia chordeilesia* from canary, 5 hours after feeding.
Fig. 5. Immature *Mosesia chordeilesia* from canary, 2 days after feeding.
Fig. 6. Immature *Mosesia chordeilesia* from canary, 5 days after feeding.
Fig. 7. Mature *Mosesia chordeilesia* from night-hawk, natural infection.


1
0.1 mm.
2
0.1 mm.
3
0.01 mm.
4
0.1 mm.
5
0.1 mm.
6
0.1 mm.
7
0.3 mm.

Host.—Insectivorous birds.
Location.—Intestine.
Locality.—Douglas Lake, Michigan.

Mosesia chordeilesia differs from *M. mosesi* as follows; the oral sucker is larger than acetabulum, genital pore more anterior, seminal receptacle much smaller, lobing of gonads not as pronounced, intestinal ceca more extended and the vitellaria less so. The author is indebted to Dr. Lauro Travassos for a private communication in which he verifies, after examining the material, the difference in the two species.

The only life cycle of a member of the Lecithodendriidae reported in the literature is that of *Lecithodendrium chilostomum,* by Brown (1933, Parasit., 25: 317–328). He found the metacercariae free in the bodies of insect nymphs. From the early post-cercarial stages he reconstructed the probable Xiphidiocercarial type. It is now known, therefore, that one member of each of the two subfamilies of the Lecithodendriidae, *i.e.,* Lecithodendriinae and Pleurogenetinae, have Xiphidiocercariae. Donald B. McMullen, *Biology Department, Monmouth College. From the University of Michigan Biological Station and the Department of Helminthology, School of Hygiene and Public Health, the Johns Hopkins University.*

SOME OBSERVATIONS ON THE AMOUNT OF BLOOD ENGORGED BY MOSQUITOES

In localities where mosquitoes are exceedingly numerous, questions have frequntly been raised as to the quantity of blood taken from animals by these pests, and whether, indeed, some deaths were not caused among animals by the loss of blood suffered in that manner.

In the course of certain field work near Portland, Oregon, the writers observed a condition which led to a study of the first of these two subjects. Flood water that had seeped into an island basin in the Columbia River early in June 1935 was observed to contain an enormous number of larvae of *Aedes aldrichi* Dyar and Knab and *A. vexans* Meig. A few days thereafter disturbance of the vegetation surrounding the water caused clouds of adults to rise. The adults persisted in the area well over a month.

The sole resident of the island was a well-nourished horse. On a number of occasions he was used as bait for mosquitoes and frequently it was possible for two collectors, working on opposite sides of the animal, to secure 100 fully engorged mosquitoes within 5 minutes. This procedure could be continued almost for hours, depending upon weather conditions. It was determined that approximatly 500 to 700 mosquitoes often fed upon the horse simultaneously, and this withont a great deal of apparent discomfort to the horse. There were approximately twice as many *A. aldrichi* as *A. vexans.*

The writers collected groups of unfed and also of fully engorged females and determined their weights by means of an analytical balance. All insects were weighed within a few hours after their capture. During this interval there was undoubtedly some loss in weight. Table I summarizes the information thus obtained.

According to these figures each engorged *A. vexans* female contained approximately $0.002077 \pm .00012$ gram of blood, or more than its original weight, and each engorged *A. aldrichi* female contained approximately $0.002107 \pm .000124$ gram of blood. Although the difference in amount of blood each species had sucked is insignificant, the smaller species, *A. aldrichi,* seems to have taken the greater quantity.

TABLE I.—*Differences in Weight Between Unfed and Engorged Mosquitoes*

Species	Unfed females			Engorged females			Difference in weight
	Number weighed	Total weight	Average weight	Number weighed	Total weight	Average weight	
		Grams	*Grams*		*Grams*	*Grams*	*Grams*
Aedes vexans	20	0.037	0.00185	45	0.182	0.00404	
	50	.090	.00180	50	.183	.00366	
	50	.087	.00174	50	.196	.00392	
Average	..	....	.001796 ± .00004	...	....	.003873 ± .00011	0.002077 ± .00012
Aedes aldrichi	50	.077	.00154	50	.177	.00354	
	50	.074	.00148	100	.380	.00380	
	50	.070	.00140	50	.170	.00340	
Average	..	....	.001473 ± .000043	...	....	.00358 ± .000117	.002107 ± .000124
Difference in amount of blood sucked by species							.000030 ± 00016

The average volume of blood drained from the horse by each female can be computed as follows:

0.002097 = average weight (grams) of blood for both species (allowing for twice as many *A. aldrichi* as of *A. vexans*)
1.0545 = specific gravity of horse blood
0.9972 = weight of 1 cc. of water at 20° C.
$0.002097 \div (1.0545 \times 0.9972) = 0.001994$ cc.

Although from 500 to 700 feeding mosquitoes were frequently counted on the horse at one time, it would seem more reasonable to base computations on the more conservative figure. The writers' observations were continued over some 30 days and for that length of time it is reasonable to assume that each of 500 females obtained a meal of at least 0.001994 cc. of blood per hour over each 24-hour period. At that rate, the horse was bled to the extent of 23.92 cc., or approximately 0.05 pint daily by the mosquito population of the island.

No marked loss of weight, if any, and no other injurious effect was suffered by the animal as far as could be determined. It might be well to add that our subject was by temperament not particularly susceptible to worry or annoyance.—H. H. Stage and W. W. Yates, *Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.*

INTESTINAL PROTOZOA IN HUMAN AUTOPSIES

In 1932 we started examining the feces and intestines of patients coming to autopsy in the Vanderbilt University Hospital, in order to discover, if possible, whether the presence of *Endamoeba histolytica* in the lumen of the intestine is always associated with macroscopic lesions in the intestinal wall. A previous study of clinic patients (1933, Meleney, H. E., Jour. Lab. Clin. Med., 19: 113–119) had shown the following incidence of intestinal protozoa on one examination: *Endamoeba coli* 12.7%, *Endamoeba histolytica* 3.0%, *Endolimax nana* 7.3%, *Iodamoeba bütschlii* 3.2%, *Giardia lamblia* 5.5%, *Chilomastix mesnili* 3.5%, *Trichomonas hominis* 1.7% and *Enteromonas hominis* 0.3%.

The actual incidence of each protozoon was presumed to be about twice as high as was found on one examination, and still higher in the case of *Trichomonas* since the fecal specimen was often not fresh when examined. It was expected, therefore, that examinations of the contents of the intestines at autopsy would yield a rather high incidence of protozoa, and that cases of infection with *E. histolytica* would be discovered in which the presence or absence of tissue invasion could be determined. To our surprise the incidence of most of the protozoa proved to be low, and for that reason and because of other interests the study was discontinued after examinations had been made in 46 autopsies.

Kerby (1935, Jour. Parasitol. 21: 449–450) has reported similar observations on 100 autopsies in Baltimore. Her only positive finding was *Giardia lamblia* in a 12-year-old boy two hours after death. This result makes it seem worth while to report our small series of observations.

In our examinations for protozoa both saline and iodine-eosin preparations were made. As soon as the intestine was opened specimens were taken from several levels of the colon. The intestinal mucosa was then examined for macroscopic lesions. Of the 46 autopsies 74% were on white patients and 26% on colored. The ages ranged from 6 months to 68 years. The age grouping was as follows: under one year 7%, 1 to 15 years 8%, 15 to 30 years 24%, 30 to 60 years 50%, 60 years and over 11%. The interval between the time of death and autopsy varied from 25 minutes to 18 hours. Fifteen per cent were examined within one hour aftr death, 50% from one to six hours, 15% from six to ten hours and 20% from ten to eighteen hours. The principal causes of death were those which would be expected in a routine autopsy series, a large majority being circulatory, cardiac and pulmonary diseases.

Intestinal protozoa were found in five cases (11.1%). The following protozoa were found: *Trichomonas hominis* (3 cases); in the colon, ileum and jejunum of an 18-month-old boy, eight hours after death from bacillary dysentery; in the colon of a 14-year-old boy, one hour after death from osteomyelitis and septicemia; and in the colon of a 59-year-old man, 12 hours after death from a lung abscess. *Giardia lambia* (1 case), both cysts and trophozoites in the sigmoid of a 45-year-old woman, 14 hours after death from cardiac failure. *Endolimax nana* (1 case), cysts but no motile forms in a 17-year-old girl, 11 hours after death from meningitis.

No macroscopic lesions could be detected in the intestine in any of the cases in which protozoa were found, except for the typical lesions of bacillary dysentery in the one case of that disease. Several of the cases in which no parasites were found showed a few small areas of petechial hemorrhage in the mucosa of the colon, but no protozoa could be demonstrated on microscopic examination of sections from these areas.

Kerby concluded from her observations that human intestinal protozoa probably do not remain in a recognizable state many hours after death. Our observations do not bear out this conclusion since we found motile *Giardia* and *Trichomonis* 12 hours or more after death, and *E. nana* cysts 11 hours after death, the cadavers having been refrigerated during these intervals. Furthermore, one would not expect protozoan cysts to become unrecognizable under such conditions if they had been present at the time of death. It seems more logical to assume that most of the patients who had harbored protozoa during health had lost them during the illness which lead to death.—William W. Frye and Henry E. Meleney, *Department of Preventive Medicine and Public Health, Vanderbilt University School of Medicine, Nashville, Tennessee.*

STUDIES IN PARASITOLOGY. V. THE INTESTINAL PARASITES IN 257 COLLEGE FRESHMEN

Fecal samples were collected from 257 of the freshmen men reporting for the physical examination at the beginning of the school year, 1935–36. These stools were collected within a period of about three days, and, consequently, had to be preserved for future study. Each stool was preserved by thoroughly mixing it with a 5 per cent solution of formalin, and was examined as time would permit. At examination the contents of each specimen container were thoroughly stirred before being strained through a double layer of gauze into a centrifuge tube, and concentrated centrifugally. Two smears were made from the concentrate of each specimen, one of which was stained with iodine, the other being examined in the unstained condition. The findings on stools treated in this manner served only as a basis for further investigation. Although all parasites encountered were recorded, no positive diagnosis for pathogenic organisms was rendered from the examination of these preserved stools alone. All persons showing pathogenic organisms, or parasites that required differentiation from pathogenic forms, were requested to supply a second or third stool to be examined in the fresh condition. The positive diagnoses recorded in this paper, then, are based on the examination of at least two individual stools (no attempt is made to give the number of stools that were examined in determining the presence or absence of the various parasites).

Results: The incidence of the various parasites encountered in the 257 individuals examined is given according to the number of times they occurred, giving the total number of cases for each parasite and their percentages as follows: Negative stools, 131, or 50.97 per cent; stools positive for one or more parasites, 126, or 49.03 per cent; *Endolimax nana,* 61, or 23.73 per cent; *Endamoeba coli,* 57, or 22.18 per cent; *Giardia lamblia,* 33, or 12.84 per cent; *Blastocystis hominis,* 30, or 11.67 per cent; *Endamoeba histolytica,* 20, or 7.78 per cent; *Necator ameri-*

canus, 8, or 3.11 per cent; *Iodamoeba williamsi,* 7, or 2.72 per cent; *Hymenolepis nana,* 4, or 1.55 per cent; *Ascaris lumbricoides,* 2, or 0.77 per cent; *Chilomastix mesnili,* 1, or 0.38 per cent; *Trichomonas hominis,* 1, or 0.38 per cent; and *Enterobius vermicularis,* 1, or 0.38 per cent.

Of the 257 individuals examined 245 came from the state of Georgia and 12 came from other states as follows: Alabama, 1; Florida, 1; Maine, 1; Maryland, 1; New York, 2; Pennsylvania, 1; Tennessee, 2; Texas, 2; and Virginia, 1. Two of the cases of *Endamoeba histolytica* were encountered in out of state freshmen, 18 cases being reported from freshmen living in Georgia. Thirty of the 33 cases of Giardiasis, and all of the cases showing *Necator americanus, Hymenolepis nana, Ascaris lumbricoides, Chilomastix mesnili, Trichomonas hominis,* and *Enteribius vermicularis* came from freshmen residing in the state of Georgia. All other parasites encountered occurred somewhat more widely distributed among the individuals examined.—Elon E. Byrd, *Zoology Department, University of Georgia.*

COMPARATIVE ACTION OF TARTAR EMETIC AND FOUADIN ON *SCHISTOSOMA MANSONI* IN VITRO

With our present knowledge Tartar emetic and Fouadin are the two best drugs for the treatment of human schistosomiasis, but there exists a disagreement in regard to which should be preferred. Tartar emetic (Potassium antimony tartrate) is administered intravenously in a 6% solution. Fouadin (Bayer product) is generally administered intramuscularly but also has been used intravenously.

The idea that a drug injected intravenously has a direct action on the parasites present in the blood stream is not correct because the human body always produces great changes in the molecular structure of the drugs injected. It seems probable, however, that by testing in vitro the direct action of these drugs on the parasites an indication of their relative efficacy can be obtained.

In regard to the direct action of Tartar emetic and Fouadin on human schistosomes there exist in the literature but few observations. Christopherson (Brit. Med. Jour., pp. 854–855, vol. II of 1920) reported that the hatching process was stopped by adding to 1/10 ccm. of urine containing eggs of *S. haematobium* 6 ccm. of tap water and 2 grains of antimony tartrate (a 2.16% solution was obtained in this way) and maintaining the jar at 130° F. Khalil (Proc. Roy. Soc. Med., 15: 13–15, 1922) confirmed the experiment of Christopherson on eggs of *S. haematobium* but stated that the hatching of the eggs is a matter of osmotic concentration of the surrounding medium and that tartar emetic acts by virtue of its being a salt and not as a specific drug that kills the bilharzia worms and eggs. Khalil determined the hatching with a temperature of 133° F. It may be noted that the high temperatures used by Christopherson and Khalil can have had a harmful action on the miracidia beside the action of the drugs.

Nishi (Scientific Repts. Gov. Inst. Infec. Diseases, 2: 485–500, 1923) experimented on the action in vitro of Sodium antimony tartrate (Stibual) on cercariae and eggs of *S. japonicum.* Cercariae in a 1% solution were almost all dead in two hours and totally dead in three hours. Eggs immersed in a 10% solution degenerated more quickly than those in water. Also this author formulated the hypothesis that the action may depend upon the osmotic pressure of the solution and might not depend upon the specific action of the drug.

Recently Lee and Chung (Proc. Soc. Exp. Biol. and Med., 32: 1400–1403, 1935) tested Sodium antimony tartrate and Fouadin on adults of *S. japonicum* and reported that Sodium tartrate showed in vitro a superior action to that of Fouadin. Adults of *S. japonicum* are killed in about 3 hours by a 0.16% solution of Fouadin in sheep serum or in ascitic fluid and in only 30 minutes in a 0.10% solution of Sodium antimony tartrate in the same media.

In the present note are reported some observations on the action in vitro of

Tartar emetic and Fouadin on cercariae, adults, and eggs of *S. mansoni*. The solutions used were sufficiently diluted to avoid the effect of osmotic pressure. One part of a 6% solution of Tartar emetic (Potassium antimony tartrate) or of Fouadin (a 6.3% solution of a colorless powder antimony III, pyrocatechin-disulphate of sodium) were added to 9 parts of rain water containing cercariae or to 9 parts of human serum in which adult schistosomes were later isolated, or to 9 parts of tap water to which a small quantity of sedimentated feces containing eggs were then poured.

The cercariae were obtained from snails (*Australobis glabratus*) infected in the laboratory. The adults were obtained from rabbits experimentally infected (about 3 months after infection). The eggs were obtained from patients recovering in the hospital. The observations were made at room temperature (average temperature in Puerto Rico in January 74.9° F.).

The results are outlined in the following table:

TABLE 1. *Action of drugs in vitro on Schistosoma mansoni*

	CERCARIAE (dilution in rain-water)	ADULTS (dilution in human serum)	EGGS	
	Time of lethal action		Prevention of hatching	
			After few minutes contact	After 13 hours contact
Tartar emetic Sol., 0.60%	1 hour and 30 minutes	11 minutes	Miracidia show very active movements	Miracidia completely immobile or moving only flame cells
Fouadin Sol., 0.63%	52 hours	20 hours	Miracidia show slow movements	Miracidia very active and eggs hatch

The results in the table show a special action of Tartar emetic on adults of *S. mansoni* more evident than that reported by Lee and Chung with Sodium antimony tartrate on *S. japonicum*. Tartar emetic tested in a 0.60% solution was also effective on cercariae of *S. mansoni* while the solution of Fouadin showed practically no effect on these larval stages. The cercariae remained living in the 0.63% solution of Fouadin for 52 hours (practically their normal period of life). This can be considered as a control indicating that no osmotic pressure on cercariae is exercised by a 0.63% salt solution. In regard to the effect on the eggs the observations made seem to agree with the conception of Christopherson that there exists a direct action of Tartar emetic on the miracidia inside the eggs. The rapid movements that are seen of the miracidia after a few minutes contact with the 0.60% solution of Tartar emetic seem to be a reaction to the drug penetrating inside the egg through its shell. The fact that the eggs kept at room temperature remain without hatching after 13 hours and the miracidia inside are immobile or move only their flame cells shows that the miracidia during this time have been killed or badly damaged. The eggs maintained in the solution of Fouadin hatch regularly. In conclusion experiments in vitro show that there exists a direct action of Tartar emetic on cercariae, adults, and eggs of *Schistosoma mansoni* and that this action is enormously superior to that of Fouadin.—ARNALDO GIOVANNOLA (*Rome, Italy*), *Fellow of the Rockefeller Foundation. From the Parasitological Laboratory and the University Hospital of the Puerto Rico School of Tropical Medicine.*

REVIEWS

Introduction to Human Parasitology. By Asa C. Chandler. John Wiley and Sons, 5th Ed. xvi, 661 pp., 1936.

In this edition the author has been quite successful in his attempt to incorporate the additions to our knowledge of the subject in the six years since his fourth edition appeared. In some places this has been done by the addition of a few phrases or sentences and in other places by completely rewriting many pages. The book continues to be a good introduction to medical zoology. It is about equally divided into three parts, namely Protozoology, Helminthology and Medical Entomology. It is interesting that the author again included the Spirochaetes under the Protozoa but makes it clear that he does not personally support this classification. Under the heading of "Parasites of Obscure Nature" he includes the Richettsia, Anaphasma and similar forms and also the Filterable Virus Diseases, particularly those once thought to be caused by visible organisms.

While the book is written, as the introduction indicates, as a semi-popular treatise on medical zoology and as a textbook for "cultural" courses in parasitology yet it is an effective text and reference book for more technical courses in Human Parasitology.—G. F. Otto.

Control of Animal Parasites. By Maurice C. Hall. North American Veterinarian, Evanston, Illinois, 162 pp., 1936.

The purpose and scope of this little treatise on the control of animal parasites is admirably stated by the author in the following paragraph taken from the preface:

"In this volume the subject of parasite control is presented on the basis of a series of diagrams and analyses of these diagrams in terms of military science. The diagrams present in visual form the factors in our problems of control, covering the life histories of parasites as lines of communication between infested hosts and susceptible host animals, together with a representation of weapons available for direct attack on the parasite in or on its host animal and for cutting the lines of communication between infested and susceptible host animals. This visual presentation is compact to an extent not readily attained otherwise. The control of parasites is treated as a form of warfare, and a body of formulated military principles has been used in this book in analyzing our control problems. This procedure, while novel, proves to be extremely useful, and the writer, with 30 years' experince in parasitology, has found that this method of dealing with parasite problems develops the facts in a situation, indicates the strength and weakness of our position, and shows what should be done much better than do the casual methods of attacking problems with which he is familiar and which are customarily employed."

This book, which is the first devoted entirely to the consideration of the basic principles of the control of animal parasites, should prove of interest to parasitologists and medical men and veterinarians who deal with the control of parasites of man and other animals. The plan of considering the fight against animal parasites in terms of Military Science has been carried out consistently throughout both in the text and in the numerous diagrams. No attempt has been made to cover all phases of the subject with equal completeness. This accomplishes one of the purposes of the author in stimulating the reader to carry the analysis further and to try to work out alternative solutions for the problems that are presented.—W. W. Cort.

AMERICAN SOCIETY OF PARASITOLOGISTS

Eleventh Annual Meeting, St. Louis, Missouri,

December 31, 1935, January 1 and 2, 1936*

Minutes of the Eleventh Annual Business Meeting

The Eleventh Annual Business Meeting was called to order by President Craig at 1:30 P. M. on Wednesday, January 1st, 1936, at the Hotel Jefferson following the annual luncheon of the Society.

I. The report of the Secretary, certified as correct by the auditing committee of the Council, was accepted and ordered filed.

The report of the Treasurer, certified as correct by the auditing committee, was presented by the Secretary. On motion, duly seconded, it was accepted and placed on file by action of the Society.

The report of the Custodian of the Permanent Secretarial Fund, copy attached, approved as correct by the auditing committee, was presented by Doctor N. R. Stoll. The report was accepted and a vote of thanks extended to the Custodian.

II. The report of the representatives of the Society on the Council of the A. A. A. S. was given by Doctor E. R. Becker. The report was accepted.

The report of the representatives of the Society on the Council of the U. A. B. S. was given by Doctor George W. Hunter. He stated that the Union is making renewed efforts to continue the publication of Biological Abstracts. He expressed the appreciation of the members of the American Society of Parasitologists concerning the value of the abstracts, but felt that the Society could not make a financial contribution to the publication of any journal other than their own official organ. This report was accepted.

The report of the Committee on Terminology was presented by Doctor W. H. Taliaferro. This report had been prepared by Doctor Hertig and dealt with the use of the terms Symbiosis, Symbiont and Symbiote. There seemed some uncertainty concerning the use of these terms by DeBary and Doctor Taliaferro suggested that the report be accepted tentatively and the commitee continued. On motion it was voted to accept Doctor Taliaferro's suggestion.

There was no report from Doctor Steiner, Chairman of the Committee on Zoological Nomenclature.

The report of the committee on the summer meeting at Minneapolis was presented by Doctor W. A. Riley, local representative. Since the official report had already been published in the Journal, Doctor Riley made only brief comments, describing the success of the meeting and his indorsement of similar arrangements next year.

The report of the Committee on Necrology was presented by Doctor W. W. Cort. He read the obituary notice of Doctor Clifford H. Alvey which had been published in the December number of the Journal of Parasitology. The Society voted that this resolution be entered in its official minutes and a copy be transmitted to the father and mother of the deceased.

The report of the Editorial Committee, certified as correct by the auditing committee, was presented by Doctor W. W. Cort. This report was accepted with thanks of the Society expressed to the Chairman of the Editorial Committee.

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* Program report has already appeared in *Science*.

III. Following the suggestion of the Council, the Society voted to participate in the next summer meeting of the Association at Rochester if a suitable representative could be found, but with the understanding there should be no financial outlay by the Society.

The Society then voted to hold its next annual meeting in conjunction with the A. A. A. S. at Washington.

The Secretary presented the recommendations of Council for officers of the Society for the year 1936. For President, Robert W. Hegner; Vice-President, William B. Herms; Members of the Council to serve for four years, Asa C. Chandler and David H. Wenrich; Members of the Editorial Board to serve for four years, Elery R. Becker, Oliver R. McCoy and Richard P. Strong. Representatives of the Society on the A. A. A. S. Council, George R. LaRue and Ernest C. Faust; Representatives of the Society on the U. A. B. S. Council, David H. Wenrich and George W. Hunter, III. The Secretary, H. W. Stunkard, and Treasurer, Justin Andrews, continue in their respective offices for one more year.

The President called for additional nominations. There were no further nominations and it was moved that the nominations be closed, that the Secretary cast one ballot for the slate as presented. The motion was unanimously passed.

The last item of business was the vote of thanks to the local representatives and to the local committee, particularly to Doctor E. V. Cowdry and Mrs. Margaret G. Eastlick, for their interest and co-operation which had contributed so much to the success of the meeting.

On motion the Society voted to adjourn.

Minutes of the Twenty-fourth Council Meeting

Due to unavoidable delay, President Craig was unable to reach St. Louis until Tuesday morning, December 31st, and at his request Vice-President H. J. Van Cleave presided at the meeting of Council, held at the Hotel Jefferson on Monday afternoon and evening, December 30th. The evening session was a joint meeting of Council and members of the Editorial Committee and Board. At the afternoon meeting, in addition to the Vice-President and Secretary, there were also present Council members Ackert, Cort, Meleney and Stoll. Doctors Ackert and Meleney were appointed by the chair as an auditing committee to examine and report on the financial statements submitted to Council.

The report of the secretary was accepted, subject to audit.

The report of the custodian of the Princeton Secretarial Fund was accepted, subject to audit.

The report of the treasurer, presented by Doctor W. W. Cort was accepted, subject to audit. The treasurer reported that the Department of Protozoology, Johns Hopkins University School of Hygiene, had provided secretarial assistance during the year and a resolution of thanks was voted by Council to Doctor Hegner for this service.

As chairman of the committee on Necrology, Doctor Cort presented the report. He read the obituary notice for Doctor Clifford H. Alvey, published in the December number of the JOURNAL OF PARASITOLOGY, and moved that this resolution be made a part of the minutes of the Council meeting and that a copy be transmitted by the secretary to Doctor Alvey's parents.

Following the report on Necrology, Doctor Cort gave the report of the Editorial Committee of the JOURNAL OF PARASITOLOGY. This report was accepted, subject to approval by the auditing committee.

The next item of business was the election of eighteen new members of the Society whose names appear on the attached list.

The Council discussed the question of summer meetings and the secretary read the report of Doctor Riley on the summer meeting held in June, 1935, at Minneapolis. It was voted to recommend to the annual meeting that the Society participate in the summer meeting next year on the same basis as last year provided a suitable

local representative can be secured. The Council voted $100 to the secretary for expense of the office for the year 1935 and $50 for expense in connection with attendance at the St. Louis meeting. Council also voted thanks to the local committee and to the local representative, Mrs. Margaret G. Eastlick, for their services in connection with the meeting. It was further voted to recommend to the annual meeting that the Society meet with the American Association next year in Washington, D. C. Sitting as a nominating committee, the Council voted to recommend to the annual meeting the following slate of officers for the ensuing year: President, Robert W. Hegner, vice-presient, William B. Herms, members of Council for four years, Asa C. Chandler and David H. Wenrich. For members of the Editorial Board, a four-year term, to replace Ackert, Becker and Strong, Elery Becker, Oliver R. McCoy and Richard P. Strong. For representatives of the Society in the A. A. A. S. Council, Ernest C. Faust and George R. La Rue. For representatives of the Society on the Council of the Union of American Biological Societies, George W. Hunter III and David H. Wenrich. The meeting recessed at 6:00 P. M. to reconvene at 8:00 o'clock when the Council would be joined by members of the Editorial Committee and Board.

The financial statement for Volume 21 of the JOURNAL OF PARASITOLOGY was presented. The estimated budget for Volume 22 was discussed and approved by the Council. Doctor Cort reported for the Editorial Committee that $98.00 had been received during the year from assets impounded in the First National Bank, Champaign, Ill. He also reported that there was still $288.00 impounded in the Baltimore Commercial Bank. Doctor Cort suggested that the $98.00 received from the Champaign Bank, during the course of the year, be allocated to the Journal Account and that all frozen assets of the Society, both in Champaign, Ill., and Baltimore, Md., be transferred to the Princeton Secretarial Fund as they become available. Such procedure, according to the recommendation of the Editorial Committee, will make it possible to write off the frozen account with a deficit for Volume 21 of only $13.32. It was moved by Doctor Meleney and seconded by Doctor Stunkard that this recommendation be adopted by the Council. It was unanimously passed and this transfer frees the Editorial Committee of carrying frozen assets from year to year in the Journal Account.

Doctor Cort made the statement that it was his wish and intention to retire as Chairman of the Editorial Committee at the expiration of his term in December, 1937, and that during the next year the Council should take steps to select a successor in order that the successor elected in 1936 might confer with the present editorial group during the year 1937. After much discussion, a motion was passed authorizing the Chairman to appoint a committee to consider the question of a new editorial committee. Since the terms of both the Secretary and the Treasurer expire at the end of 1936, it was further suggested that this committee consider the nomination of new officers for the Society as well as new members of the editorial committee. J. E. Ackert was appointed Chairman of this committee and with him the following members: Becker, Chandler, Cort, Faust, La Rue, Meleney, Riley, Stoll, Stunkard, Taliaferro and Van Cleave.

The meeting adjourned at 11:30 P. M.

Respectfully submitted,

H. W. STUNKARD, *Secretary.*